THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA.

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1910-1914

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SESSION OF 1910-11

ANNUAL BUSINESS MEETING.

Assembly Room, N. S. Technical College, Halifax;
14th November, 1910.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

The Institute had been called together for the annual business meeting, but as the greater part of the evening had been occupied with a meeting of the Nova Scotia Society of Engineers, to which the Institute's members had been invited, on motion it was resolved that the annual meeting be adjourned to a future date.

ADJOURNED ANNUAL BUSINESS MEETING.

Civil Engineering Lecture Room, N. S. Technical College, Halifax;
12th December, 1910.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

Other members present: WATSON L. BISHOP, MAYNARD BOWMAN, F. W. W. DOANE, DONALD M. FERGUSSON DR. JOHN STEWART, GEORGE R. BANCROFT, S. A. MORTON, PHILIP A. FREEMAN, and HARRY PIERS.

PRESIDENTIAL ADDRESS: (1) Progress of the Institute; (2) Some Achievements of Chemical Synthesis.—By PROFESSOR E. MACKAY, PH. D., Dalhousie University, Halifax.

PROGRESS OF THE INSTITUTE.

We enter this evening upon the forty-ninth session of the work of the Institute of Science. Owing to the postponement of the annual meeting, in order to meet in joint session with the Engineering Society, our formal opening is exceptionally late, and the session in consequence will be comparatively short. Let me express the hope that it will nevertheless prove to be the most prosperous and productive in the history of the Society.

The year closed has been happily free from any losses to our membership through death. Another gratifying feature has been an increase in the average attendance at the monthly meetings. Eleven papers were presented, including two in the department of Biology, three in Geology and Mineralogy, two in Physics and three in Chemistry. The attention of the Society was thus about equally divided between the natural and physical sciences. The Treasurer's report, which will be submitted to you, will show that the financial condition of the Society is more favourable than for either of the two preceding years. A special effort was made during the year to collect membership fees, with the gratifying result that the revenue from this source has been seventy-five per cent greater than that for last year and a hundred per cent greater than that received two years ago.

The outstanding feature of the year has been the installation of the Institute and its property in its present convenient and commodious quarters. In the Autumn, through the courtesy of the Nova Scotia Technical College, we found a permanent place of meeting in the College building: and in May and June the Provincial Science Library, of which the library of the Institute forms nearly eighty per cent, was removed to the new library room in the west wing of the College building, where, at the present rate of growth, the librarian estimates there will be accommodation for seventeen or eighteen years to come. The increased space has made the complete classification and arrangement of the library possible and owing to the untiring efforts of the librarian, Mr. H. Piers,

all books are now readily accessible. The Provincial Museum also, as soon as it is practicable to move it, is to find a new and more commodious home in the Technical College. These changes mark an important advance. When they are completed the whole of the large and valuable equipment in museum and library will be for the first time readily accessible to every scientific worker who wishes to use it.

We enter upon the new session of the Institutes' work with a membership of 93 including 74 ordinary and associate and 19 corresponding members. Ten years ago we had 100 ordinary and associate and 25 corresponding members, a total of 125 members. Judged by these statistics, we should have to admit that instead of growing we had declined twenty-five per cent. It is only fair to remember, however, that on account of the successive prunings to which our lists have been subjected in recent years, the decline shown has been nominal rather than real and that our effective membership has probably been maintained. We must also recall that within a few years a flourishing sister society, the Engineering Society, has been organized, and that it appeals in considerable measure to the same constituency as the Institute does. Making due allowance for these considerations, the fact remains that while there has probably been no real decline, we have not grown as we ought. It would be too hasty to draw the conclusion that our younger men are not furnishing their due proportion of investigators. To go no further back than ten years, I can recall at least ten young men who while here contributed one or more papers to the Institute, and of whom few or none are now in the Province. If we could have diverted to our own Transactions the researches which these young men have published since leaving us and which have gone to enlarge the stock of knowledge under other auspices than ours, we should have much less reason to complain of lack of scientific activity. We are, in fact, in this as in some other respects, paying the tribute to larger communities which, it would seem, comparatively small communities are obliged to pay.

Within the last decade the people of Nova Scotia have come to a higher appreciation of the value of scientific education, and the facilities for scientific work have much increased. For evi-

dence of this we have only to look around us at the present moment. The building in which we are meeting and its equipment prove that the public is realizing how indispensable is the service which science renders the community. The Technical College will add considerably to the facilities for scientific instruction and research; and we may look to it with confidence to make large additions to our knowledge— more especially in applied science. In the older provincial colleges, also, the most noteworthy progress in recent years has been in the expansion of the scientific departments, shown in the opening of new laboratories or in important additions to staff and equipment. All this implies that scientific work is receiving more serious attention in our Province now than at any previous time, and the conditions for the growth of a Society devoted to the promotion of scientific research should not at least be less favourable than they have hitherto been. This consideration should stimulate us to energetic efforts in order to realize more fully than we now do the purpose for which the Society exists.

As the purpose of the Institute is to promote research, the true index of its prosperity is not the length of its membership list, but the quality and quantity of its contributions to knowledge. Progress here is more difficult to estimate, but a careful survey of our yearly Transactions leads to the conclusion that we are doing little, if any, more than maintaining the position of ten or twenty years ago. Can we do anything to stimulate progress?

The Institute has in the past endeavoured to promote investigation principally in four ways: (1) by undertaking the publication of scientific investigations; (2) by accumulating a library and making it accessible to all who desire to use it; (3) by associating together those interested in scientific investigation with a view to stimulating individual effort; and (4) by attempting to arouse general interest in scientific work.

It will be admitted that we have not been equally successful in these various directions. We have, in the first place, succeeded in publishing with fair regularity the papers presented to the Society. In regard to our library we can point with satisfaction to our considerable and growing collection of publications of

scientific societies, conveniently arranged, within ready access of our place of monthly meeting, and accessible daily not only to our own members but to the general public and especially to students of pure and applied science. The material in our library is, as far as it goes, just the kind which the scientific investigator needs. No library of text-books could take its place, and as it is the kind of library which would not have been collected in this Province but for the efforts of this Society, we have here an achievement in which it may be permitted us to glory. At the same time, as an antidote to excessive pride, we may remember that there are many serious gaps on our shelves and that in particular the most important journals of Physics and Chemistry are conspicuously absent, as these cannot be obtained by exchange but only by purchase.

When we turn to the other two directions specified in which an effort has been made to promote research we do not find the record so successful. The Institute has not yet succeeded in organizing and associating the scientific interests in its territory; and little direct effort has been made to awaken general interest in scientific work.

Now let us consider briefly what it is desirable for us to accomplish in these two directions.

Enthusiasm in advancing science like religious or political enthusiasm, or indeed any other kind, is powerfully promoted by close association and frequent meetings of those of similar ways of thinking. The exhortation of the Apostle to the early Christians not to forsake the assembling of themselves together, was founded upon a knowledge of the needs of human nature. The scientific investigator is cheered and stimulated by frequent association with fellow-workers, and his zeal tends to languish if he finds himself cut off from them. Hence a disproportionately large amount of research work is done in the centres where men meet each other frequently. In this Province we have no large communities; and we can only very imperfectly at best overcome the isolation of individual workers. In order to do what we can in this direction the first step is to have all actual or potential workers so far as possible become members of the Institute. We should carefully

survey our territory, district by district, and see that the claims of
the Society are placed before every man believed to be interested
in scientific work. Every teacher of Science, more especially every
teacher of the natural sciences, should be on our membership list.
The professional and business men who have become interested in
some department of science, the more progressive of our farmers,
fruit-growers and fishermen, all these should have an opportunity
of identifying themselves with the Institute's work. Men com-
petent to make reliable observations of natural phenomena, who
have at the same time both the inclination and opportunity to make
them, are not very numerous. The services of all such are needed
in the Society. An ideal to be realized would be to have a com-
petent observer in every important district of our territory who
would report upon any natural occurrence of scientific interest
in his district, for example, on the appearance of any insect
pest or other agency destructive to vegetation, or the occur-
rence of local earthquakes, or of unusual meteorological or
celestial phenomena. There is nothing new in the attempt to
realize something of this sort. The Education department of Nova
Scotia inaugurated a system for the purpose of making phenolo-
gical observations many years ago and the experience gained by
the department would be invaluable in any attempt to organize a
corps of observers among associate members of the Institute.
Accordingly, I wish to be understood as speaking with diffidence
of what the possibilities in this direction may be. But whether it
is practicable to stimulate observation by organization of this kind
or not it is certain that we must make a systematic effort of some
kind in order to retain the interest and support of non-resident
members. It would probably not be difficult to largely increase
our membership. Our entrance fee is not formidable, and initia-
tion ceremonies are simple. The real problem is how to maintain
an interested and, in consequence, effective membership; and this, it
seems to me, can only be done by keeping in frequent communica-
tion with members in one way or another. If we were a large and
wealthy society, able to issue a monthly or fortnightly journal to
all members, the problem would be solved. But our transactions
are issued much too seldom to have the desired effect. Hence some

other means must be adopted; and to bring the discussion to a practical issue, I would make the following suggestions:—

(1) That reports of our monthly meetings, or of lectures or other functions under the auspices of the Society be sent every member regularly. This might perhaps be done with least trouble and without much expense by making suitable arrangements with the city newspapers.

(2) That if possible there should be held annually a special meeting of the Institute, preferably at some time when there are excursion railway rates to the city; that the programme of this meeting should be made of as great general interest as possible; and that there should be opportunity at it for the discussion of matters specially affecting non-resident members.

(3) That as many competent observers as possible should be organized in observational work, mapped out by and under the direction of the Institute.

That part of the Institutes work designed to awaken public interest in science has not hitherto received much direct attention from the Society. All are agreed, however, that it is important, both as an end in itself, and as a means to the end for which the Society exists.

There are occasions when arousing public interest in scientific matters becomes an imperative duty which a scientific society must not shirk. The advent of the brown tail moth is an example of such an occasion. And other occasions frequently occur offering opportunities to a Scientific Society to be of public service. I am reminded in this connection that not many months ago I heard a city official give an address in which he scoffed at the idea that the common house fly could be a carrier of disease. This example illustrates a dangerous sort of ignorance which a popular scientific lecture on the habits of the house fly might perhaps remove. And if the Institute could occasionally provide such lectures on timely topics it would earn public gratitude, and incidentally do much to educate the public to appreciate the value of scientific work and to become interested in it.

It would be easy to suggest numerous ways of promoting investigation and interest in investigation, which could be made

effective if we had unlimited resources to draw upon. But what concerns us most at present is, not what we might do if we had the means but what we can do with the means we have. The Institute is able to look back upon a past of solid achievement; it finds itself at present in a more favourable condition as regards material appliances than it has ever before been. May it not, therefore, look forward with confidence to a future that will be worthy not merely of the achievements, but of the hopes and aspirations of the past?

Some Achievements of Chemical Synthesis.

In addressing you a year ago, I attempted to trace the development of the atomic theory, and to show how its fundamental conception had received striking and unexpected confirmation from recent physical research. This evening I propose inviting your attention to a few achievements of Chemistry in the synthesis of organic compounds. It is a subject which opens up a vast, almost illimitable, field, in which one might wander indefinitely. But in the time at my disposal it will only be possible to glance briefly at a few out of very many notable results obtained; and if, in addition, I succeed in presenting such a general conception of the nature of synthetic problems as may be possible without introducing technicalities, my object will have been attained.

Numerous as the different kinds of substances we meet in Nature may seem to us, they form but a small portion of the vast array of substances known to Chemistry. In other words, by far the greater proportion of existing substances are manufactured. Some of these, like phosphorus or sodium, are elementary substances, and hence their preparation involves the splitting up of the compounds used as raw material. Others, like sulphuric acid, or white lead, or rosaniline are compounds, and so have to be built up from the constituents of the raw materials used in their manufacture. This building up process is chemical synthesis, and it is in this direction that Chemistry has achieved some of its most notable triumphs.

The Chemical elements vary greatly in their capacity for forming compounds. Argon and helium, which cannot combine with

anything, illustrate one extreme of this capacity; while carbon, whose compounds number considerably more than a hundred thousand, illustrates the other. The overwhelming superiority of carbon in respect of its compound-forming capacity is one of the cardinal facts of Chemistry. Its compounds include all substances of vegetable and animal origin; thus starch, sugars, fats, and that exceedingly complex group of substances, the proteins, which make up the chief part of the white of egg or the protoplasm of cells, are all compounds of carbon. This great group of substances known as organic compounds, formed the dark continent of early chemical exploration. Until about a century ago only a very few of the most venturesome had dared to enter the territory at all. There was a mysterious something about organic substances which distinguished them from inorganic or mineral compounds, a something which, as a leading chemist of the time said, was easier felt than defined. One distinction between the two came to be universally accepted, namely, that only inorganic compounds could be built up in the laboratory from their elements. Organic compounds, on the other hand, could only be formed in organisms, under the influence of vital force.

This belief received a shock in 1828 when Wöhler, a distinguished German chemist, accidentally discovered that ammonium cyanate, commonly classed as an inorganic compound, could be readily converted into urea, a typical organic substance. It is not easy for us now to realize how startling this discovery seemed to the chemists of that time. If a modern chemist were to discover that living cells could be developed from ammonium salts, the discovery would scarcely produce a greater sensation. Wöhler's discovery showed that the synthesis of organic compounds was possible in the laboratory and that therefore the mysterious influence called vital force was not a necessary factor in their formation. Why, then, would it not be possible to make, starch, sugar, the fats, even muscular fibre from their elementary constituents? And so this first organic synthesis opened up to the vision of chemists a vista of possibilities hitherto undreamt of and pointed the way to an illimitable field for investigation and discovery.

It was long, however, before the next organic synthesis was effected. This was the synthesis of acetic acid, the acid of vinegar, and was carried out by Kolbe in 1845. Two relatively simple organic compounds had thus been synthesized in somewhat less than twenty years. This was slow progress. And in learning why advance had not been more rapid we shall learn something of the nature of the problem presented by organic synthesis.

Let us suppose that a clever workman who had never seen a watch finds one some day and, observing its usefulness, wishes to construct one for himself. Let us further suppose that he is permitted to experiment with the watch and to observe its exterior but that he cannot open it and that, therefore, the internal mechanism is invisible to him. Having learned everything possible from observation, his next step would be to make an hypothesis about the structure of the watch that would satisfactorily explain its observed behaviour. Then, having purchased the necessary parts from a dealer, he would proceed to put them together in accordance with his hypothesis. If the latter were well-founded the result would be a watch, the counterpart of that studied.

Now the problem which our amateur watch-maker had to solve is crudely analogous to the much more complex problem which confronts the chemist who attempts to synthesize an organic compound. First he has to determine the composition of the given compound; then to observe its behaviour under various conditions; then to make an hypothesis about its structure that satisfactorily explains the observed behaviour; finally, he has to cause the proper kinds of matter to unite in such a way as to give a compound of the assumed structure. If the assumed structure were correct, the result will now be the desired compound.

In the time of Wöhler, to determine the composition of a substance was in general much the easiest part of this problem; for methods of analysis had already been perfected. It was only necessary to obtain a pure specimen of the substance to be analyzed. This, indeed, sometimes was, and still is, a very difficult task. But as a rule, the nature and proportions of the constituents of a compound could be accurately ascertained without great difficulty.

It was far otherwise with the structure. Dalton's atomic hypothesis was already nearly quarter of a century old when Wöhler

synthesized urea. According to this hypthesis when a compound of, say, carbon, hydrogen and oxygen is formed, the smallest particle of the compound capable of existing is some sort of little group or association of definite numbers of atoms of carbon, hydrogen and oxygen; and any given portion of the compound, say a pound of it, is simply an exceedingly large number of such little groups, massed together. These little groups of atoms are now called molecules. This picture of what we may call the invisible mechanism of matter may or may not be a true one; but the true mechanism, whatever it is, produces exactly the same visible effects as would result from the atomic hypthesis. This hypthesis, therefore, as far as it goes, serves the same practical purposes as a knowledge of the actual constitution of matter. It will be noticed, however, that it only provides us with a skeleton mechanism, leaving details to be filled in; and chemists soon felt the need of supplementing it with additional hyptheses. Wöhler's discovery, already cited, furnishes an illustration of facts which made this need apparent. Ammonium cyanate and urea have exactly the same composition, which is expressed in terms of the atomic hypothesis by the formula CH_4N_2O ; that is, in every smallest particle or molecule we may suppose that one atom of carbon is associated with four of hydrogen, two of nitrogen and one of oxygen. It cannot be that these different atoms are associated in haphazard fashion, like so many different coloured marbles thrown into a bag. On the contrary, there must be one definite arrangement of them that gives ammonium cyanate and another that gives urea. So much is evident; but how is the arrangement in each case to be determined? And until the arrangement of atoms in the molecule of a given compound is known, or whatever it is that corresponds to this in the true mechanism of matter, how is the synthesis of the compound to be anything more than a lucky chance?

It is now clear why progress in the synthesis of organic compounds had been slow. The problem of constitution had first to be solved or at least some working hypothesis had to be formulated which would be a sufficient approximation to the truth to serve practical purposes. The history of Chemistry from 1820 to 1860 is characterized by successive attempts to attain this end. Berzelius' electro-chemical theory, the radical theory, the substitution theory,

the newer type theory, and finally the theory of valence, mark notable steps in the progress. Each successive theory explained a wider range of facts than its predecessor, and gave place in turn to a theory capable of interpreting a yet wider range. We are here concerned only with the last-named, the theory of valence. This theory attributes to each atom a strictly limited capacity for combining with other atoms, as measured by the number of atoms with which it can combine. Accordingly, an atom cannot combine with or, figuratively speaking, become linked to, an indefinitely large number of other atoms, but only with a small number, the atoms of different elements having different capacities in this respect. For example, an atom of hydrogen, or of chlorine can never combine directly with more than one other atom and these elements are therefore called univalent. The capacity of an oxygen atom for combination is exhausted by combining with two atoms of hydrogen or any other univalent element; and hence oxygen is called bivalent. An atom of carbon can combine with a maximum of four hydrogen or four chlorine or two oxygen atoms, that is, carbon is tetravalent. With the aid of this hypothesis it was now possible to interpret experimental results by the formulation of relationships between the atoms of a molecule. An example will make this clear. The composition of alcohol is expressed by the formula C_2H_6O. Now one-sixth of the hydrogen and all the oxygen are removable from alcohol, and re-appear together again in one of the reaction products. These experimental results can be interpreted by attributing to one of the hydrogen atoms a different relation to the compound from that of the other five, and by supposing that this hydrogen atom is directly combined with the oxygen atom. But as hydrogen is univalent and oxygen bivalent, these relations would have to be expressed by the formula C_2H_5-O-H. Interpreting in similar fashion other reactions of alcohol, and assuming the tetravalence of carbon, we finally arrive at the formula CH_3-CH_2-O-H which expresses relationships between the atoms. Now formulae of this kind—known as structural or constitutional formulae—not only suggest new properties, but also methods of synthesis. For example, the above formula suggests a method of making alcohol from the

hydrocarbon, ethane. The latter is a gaseous compound whose structure is represented by the formula $CH_3\text{-}CH_3$ By the action of bromine upon it we obtain bromethane, $CH_3\text{-}CH_2\text{-}Br$, a pleasant smelling, volatile liquid. Acting on this with a suitable metallic hydroxide should replace the bromine by an oxygen and hydrogen atom and hence should yield alcohol if our constitutional formula is correct,—

$$CH_3\text{-}CH_2\text{-}Br + MOH = CH_3\text{-}CH_2\text{-}OH + MBr.$$
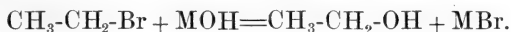
This result has been experimentally verified.

In the constitutional formula of alcohol just given, the assumption is made that one atom of carbon can combine with another. An extension of this assumption explains the remarkable compound-forming capacity of carbon already mentioned. By supposing that one atom of carbon can combine with another, one of these with a third, this in turn with a fourth, and so on, we should obtain a structure analogous to a chain, of which carbon atoms are the links. No other element seems to have any appreciable power of forming such atomic chains, and on the other hand there appears to be practically no limit to the number of carbon atoms that can enter into the carbon chain. Hence the multiplicity and complexity of carbon compounds, and the variety and difficulty of the problems presented by the synthesis of them.

We owe the theory of valency to the labours of Frankland, Couper, and Kekulé. With its development, progress in the formulation of the constitution of carbon compounds became exceedingly rapid; and no less rapid was the advance of organic synthesis, for the determination of the constitution of a compound usually implied that either immediately, or at all events in no long time, methods would be devised for the synthesis of it. In this way, one by one, many of the organic compounds found in Nature were artificially prepared. But numerous as these preparations were they formed but a small fraction of the stream of carbon compounds entirely new to the world which now began to pour from chemical laboratories. The stream became a flood when a few years later, Kekulé, in a memoir regarded as the most brilliant piece of reasoning in the literature of organic chemistry, showed how the theory of valency could be applied to explain the

peculiarities of a class of substances known as the aromatic compounds, which until then had presented a hopeless jumble of unintelligible reactions. This explanation constitutes what is called the benzene theory. Its effect in stimulating activity in organic chemistry, and more especially in organic synthesis was immediate and unexampled. The aniline colur industry, which it found small and helpless, forthwith became great and powerful. Even now, although forty-five years have passed since the benzene theory was published, its fertility remains undiminished. To quote from Professor Japp: "Kekulé's work stands pre-eminent "as an example of the power of ideas. A formula, consisting of "a few chemical symbols jotted down on paper and joined together "by lines, has . . . supplied work and inspiration for scien- "tific organic chemists during an entire generation, and affords "guidance to the most complex industry the world has yet seen."

It remains to cite a few examples of the achievements of organic synthesis. I shall have to pass by the almost innumerable essences, perfumes, colurs, anaesthetics, antispetics, and substances of therapeutic value, which we owe to this branch of Chemistry: and I can only linger long enough to merely mention the synthesis of camphor, and of the natural alkaloids, nicotine, atropine, conine, and cocaine, to mention some of the better known. But I shall venture to dwell a few moments on what has been accomplished in the synthesis of three important groups of substances produced in living organisms: (1) the sugars, (2) the proteins and (3) the vegetable dyes. As I have undertaken to avoid technicalities, the merest glance at these different fields must suffice.

The sugars, as is well known, form a very important natural group of substances closely related to starch, cellulose and the gums. The best known sugars belong to either one of two groups. Cane, malt and milk sugar, all having the composition expressed by the formula $C_{12}H_{22}O_{11}$ are called disaccharoses. Glucose or grape sugar and fructose or fruit sugar, having the formula $C_6H_{12}O_6$ are monosaccharoses. Until a little over twenty years ago, in spite of the importance of the sugars, little was known of their chemistry. This was not because they had not been studied but because of the hopeless character of the problem they presented.

It is to the work of Kiliani and especially to that of Emil Fischer that Chemistry is indebted for the solution of these problems. In 1866 Kiliani succeeded in determining the constitution of both glucose and fructose; and within the following four years Fischer not only synthesized both glucose and fructose, but also a large number of other related sugars previously unknown, and succeeded in completely clearing up the Chemistry of the whole group of saccharoses. Fischer's brilliant work was made possible by his discovery of a means of effecting what had baffled earlier chemists, the isolation of a sugar in pure condition from a mixture. The key to this problem he found in the reagent, phenylhydrazine, which he discovered would convert a sugar into an easily purified, easily identified, insoluble compound. But it requires a magician to wield a magician's wand: and phenylhydrazine in the hands of any less gifted worker would not have accomplished what it did in the hands of Emil Fischer. When after a few years work he finished his investigation of the monosaccharoses, that chapter of Chemistry was left practically complete.

The syntheses in the group of disaccharoses have been much less numerous. The most notable has been that of cane sugar, and with a passing reference to the way in which this has been accomplished we shall leave the sugar group.

When cane sugar undergoes inversion it takes up the elements of water and yields equal quantities of glucose and fructose. This and other reactions indicate that cane sugar is some sort of compound of glucose and fructose with water eliminated. The glory of first succeeding in producing such a compound is due to Marchlewski, who obtained cane sugar by the reaction of aceto-chloroglucose on potassium fructosate in 1899.

When we turn to the protein group we have to deal with the most complex substances known to Chemistry. At the same time their relation to the living organism makes them physiologically the most important of all substances.

The difficulty of research in this branch of organic chemistry are enormous. Many members of the group are non-crystalline substances, and hence excessively difficult, or impossible, to obtain in pure condition. Again they are, as a rule, very sensitive

to changes of temperature and to the action of reagents, which of course greatly increases the difficulty of unravelling the nature of reactions. Finally they are substance of prodigious complexity—egg albumen having a molecular weight not less than 12 or 15,000.—that is to say, there must be several hundred atoms of carbon in the molecule. In spite of these difficulties, however, much progress has been made in the chemistry of the proteins in recent years; and the chief progress has been due to the application of synthetic methods. The magician under whose direction these methods have been carried out is Emil Fischer. Let us glance at the results.

When the huge protein molecule is broken up by the action of chemical reagents, such as acids and alkalies, the fragments consist of substances which can be analyzed and identified. They are found to belong for the most part to a class of substances known as amino-acids, of which amino-acetic acid (glycocoll) is a simple example:

$$CH_2NH_2CO_2H.$$

Now the manner of breaking up of the protein molecule is of such a kind that it is practically certain the parts represent veritable fragments or are closely related to veritable fragments of the original molecule. The work of Emil Fischer and his students has been devoted to piecing together these fragments in the way in which it seems most probable they ought to be combined. To show the nature of this piercing together let us begin with amino-acetic acid. It contains a group NH_2CH_2CO, which Fischer calls glycyl. Now this may be made to combine with amino-acetic-acid so as to yield the following:

glycyl,-glycine, NH_2CH_2CO - $NHCH_2CO_2H.$

In the same way we obtain:

diglycyl-glycine, NH_2CH_2CO - $NHCH_2CO$ - $NHCH_2CO_2H.$

And this chain may be lengthened indefinitely. Now by substituting in a similar way other amino-acid groups as leucyl, C_4H_9- $CH(NH_2)CO$, other similar compounds are obtained. These compounds are named by Fischer the polypeptides. One of these has been synthesized which contains eighteen amino-acid groups like the above joined together, giving the enormous mole-

cular weight of 1213—truly a masterpiece of synthetic skill. Now a remarkable fact is that these polypeptides have properties which are quite different from those of the amino-acids of which they are made up and approach closely the properties of proteins. They give, for example, some of the characteristic reactions of the proteins, and when they are fed to animals the products are the same as in the case of albumens. These results indicate that the advances now being made so rapidly are in the right direction and that the goal of the strenuous efforts being made, the synthesis of a veritable protein, is not beyond the power of organic chemistry.

In turning now to the group of vegetable dyes we leave pure science behind and deal with science in partnership with commerce and industry. For unlike the monosaccharoses and polypeptides with which we have been dealing, alizarin and synthetic indigo are articles of commerce which have competed with, and displaced, the vegetable dyes madder and indigo. Alizarin was the first but indigo is the greatest achievement of synthetic chemistry in this field. Many syntheses of it have been long known, the first having been effected in 1870. The problem of the commercial synthesis of indigo, however, involved other factors besides the purely scientific ones; and its solution is a magnificent tribute not only to the synthetic skill and the perseverance, but also to the business sagacity, of those workers who for twenty years never faltered in their determination to reach the desired goal.

The first attempts to place the synthesis of indigo on a commercial basis started from toluene, one of the constituents of coal tar, as raw material. From this substance there are numerous paths leading to indigo. Some of these perpetually lured the investigator on with the hope, so often elusive, that means could be devised of reducing the cost of production to such an extent as to make the route a commercial one. One of these routes led to indigo through a substance called authranilic acid. Then forthwith the dominant factor in the problem became the production of this acid at a sufficiently reduced cost. A method of making it from napthalene instead of from toluene was discovered, and this discovery was the turning-point of the struggle. "At one stroke" says one of the investigators[1] "the commercial manu-

"facture of indigo was placed on a solid basis. From that moment
"I had the firm conviction that the method on which we were
"engaged would bring us to the desired end.". The reason of this
confidence lay in the fact that napthalene as raw material had the
great advantage over toluene of being very much cheaper and more
abundant; so much so that nearly 30,000 tons of napthalene
annually were being converted into lamp black, or left unisolated,
for lack of more profitable use.

Success, however, was not yet won. Besides the solution of
numerous minor difficulties, it involved the devising of a cheaper
method of producing concentrated sulphuric acid; and thus it
has happened that it is to the struggle for synthetic indigo we
owe the introduction of the contact process of manufacturing
sulphuric acid which has already revolutionized this, the greatest
of chemical industries.

It is now nearly a decade since the goal so long striven for
was at length gained, and synthetic indigo was able to compete
successfully both in quality and cost with the natural product.
In 1901 the whole of the indigo imported into Great Britain was
the product of the indigo plant. In 1908 synthetic indigo to the
value of $670,000 was imported, or about one half of the total
importation. It requires no prophet to foretell the conclusion of
the story: the industry of indigo production will pass from the
banks of the Ganges to those of the Rhine. And the moral is
equally plain. It is the country that is most successful in making
science not merely the occasional adviser of the industries, but their
ally and confidant, that will be victor in the contest for industrial
supremacy.

The Treasurer, M. Bowman, presented his annual report,
showing that the receipts for the year 1909-10 were $849.19, the
expenditures $609.45, and the balance in current account on 31st
October, 1910, was $236.74; while the permanent endowment fund
is $859.81, and the reserve fund, $190.68. The report having been
audited, was received and adopted.

The Librarian's report was presented by H. Piers, showing
that 1754 books and pamphlets had been received by the Institute
through its exchange-list during the year 1909; and 1456 had been

received during the first ten months of the present year (1910), viz., January to October, inclusive. The total number of books and pamphlets received by the Provincial Science Library (with which those of the Institute are incorporated) during the year 1909, was 2204. The total number in the Science Library on 31st December, 1909, was 38,988. Of these, 30,587 belong to the Institute, and 8,401 to the Science Library proper. That is, about 78 per cent. are the property of the former, and about 22 per cent. belong to the latter. 431 books were borrowed, besides the many that were consulted in the library. No binding was done during the year, there being no grant available for the purpose. From 13th May to 17th June, 1910, the whole Science Library was moved from No. 201 Hollis Street, where it had been located since its foundation in 1900, to the large new stack-room provided for it in the Nova Scotia Technical College, Spring Garden Road, and since then it had been entirely checked over, book by book, and rearranged.—The report was adopted.

The following were elected officers for the ensuing year (1910-11):

President,—WATSON L. BISHOP, *ex-officio* F. R. M. S.

1st Vice-President,—DONALD M. FERGUSSON.

2nd Vice-President,—PHILIP A. FREEMAN.

Treasurer,—MAYNARD BOWMAN, B. A.

Corresponding Secretary,—ALEXANDER H. MACKAY, LL. D., F. R. S. C.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—ALEXANDER McKAY; PROFESSOR FREDERIC H. SEXTON, B. SC.; FRANCIS W. W. DOANE, C. E.; A. L. McCALLUM, B. SC.; PARKER R. COLPITT; GEORGE R. BANCROFT, B. A.; and PROFESSOR EBENEZER MACKAY, PH. D.

On motion, a vote of thanks was presented to the retiring President, DR. E. MACKAY, for the unusually able and satisfactory manner in which he had filled the chair during his three years term of office, the limit of time allowed by the by-laws.

FIRST ORDINARY MEETING.

Civil Engineering Lecture Room, N. S. Technical College, Halifax;
13th May, 1911.

THE PRESIDENT, WATSON L. BISHOP, in the chair.

A paper by WALTER HENRY PREST, of Bedford, N. S., entitled, "A Suggestion for Anthropological Work in Nova Scotia," was read by DR. A. H. MACKAY. (See Transactions, p. 35.) The subject was discussed by DR. MACKAY, H. PIERS, Dr. E. MACKAY, G. W. T. IRVING, and the author. The consideration of what, if any, exploratory work might be undertaken, along the line suggested by the paper, was referred to the council. (For the results of such work, see W. H. Prest's "Report on Cave Examination in Hants County, N. S.", in Transactions, vol. xiii, pt. 2, p. 87.)

SECOND ORDINARY MEETING.

Reading Room, N. S. Technical College, Halifax;
31st May, 1911.

THE PRESIDENT, WATSON L. BISHOP, in the chair.

It was announced that the following had been duly elected ordinary members by the council: C. B. NICKERSON, M. A., demonstrator in chemistry; CLARENCE D. HOWE, B. Sc., professor of civil engineering; HOWARD L. BRONSON, professor of physics; D. S. MACINTOSH, B. Sc., lecturer on geology; and HAROLD S. DAVIS, B. A.; all of Dalhousie University, Halifax.

On motion of H. PIERS and A. L. MCCALLUM, it was resolved that the Nova Scotian Institute of Science learns with deep regret of the death of its corresponding member, DR. ROBERT WHEELOCK ELLS, F. R. S. C., and desires to express its high appreciation of him and of the very valuable work he had done for Canadian geology, particularly in the Maritime Provinces.

The following papers were read by title:

1. "Recent Meteorological Notes."—By F. W. W. DOANE, city engineer, Halifax. (See Transactions, p. 53.)

2. "Monthly Mean Temperatures, Halifax, N. S., and Plymouth, G. B., compared."—By HENRY S. POOLE, D. SC., F. R. S. C. (See Transactions, p. 52.)

3. "Mineral Occurrences in Granite at New Ross, Lunenburg county, N. S."—By A. L. MCCALLUM, B. SC., Halifax.

4. "On the Effect of Gravity on the Concentration of a Solute."—By HAROLD S. DAVIS, B. A., Dalhousie University, Halifax. (See Transactions, p. 291.)

5. "Rare Fishes in Nova Scotia."—By HARRY PIERS, curator of the Provincial Museum, Halifax.

HARRY PIERS,
Recording Secretary.

PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1911-12

ANNUAL BUSINESS MEETING.

*Electrical Engineering Lecture Room, Technical College,
Halifax; 13th November, 1911.*

THE PRESIDENT, WATSON L. BISHOP, in the chair.

Other members present: PROF. E. MACKAY, M. BOWMAN, F. W.
W. DOANE, P. R. COLPITT, W. McKERRON, PROF. C. L. MOORE,
DR. H. JERMAIN CREIGHTON, PROF. D. S. MACKINTOSH,
PROF. C. D. HOWE, H. S. DAVIS, and H. PIERS.

PRESIDENTIAL ADDRESS: (1) Review of the Institute's Work,
(2) Death of Dr. R. W. Ells.—By WATSON L. BISHOP.

Gentlemen,—As we are entering upon another year it gives
me the opportunity to call your attention to the work of the year
which is gone, in order to stimuate further improvement.

We have at last, as an Institute, found an ideal home in the
Technical College—the provincial centre of Science *applied*. We
have not only comfortable but aesthetic rooms for meeting—large
or small to suit the size of the audience. We have at hand
facilities for illustrating papers, popular or scientific, to which for
nearly half a century the Institute has been a total stranger. We
have a large staff of scientific professors at home in the same
building and an increased staff of scientific men at Dalhousie
University. But all this wealth of facilities failed during the past

Dalhousie. But all this wealth of facilities failed during the past year to produce the output of the old strenuous days when we met in the poorly lighted, badly seated, and primitively warmed and ventilated museum on Cheapside.

It is true, the Institute of 1863 has lost heavily by emigration. The medical doctors formed an association of their own. Those developing mining industries branched out into the Mining Society, of Nova Scotia; and later the engineers swarmed out to form their own hive. But while making allowance for all this, there should surely be better conditions for the development of the scientific cult to-day than ever before. It is therefore with some disappointment I refer to the work of last year. It has not come up to our improved opportunities. Our men of science have been too completely engrossed in the increasingly exacting duties of their various routine public services. We must not forget, however, to keep the vestal fire of scientific research alive in this focus of the community. That is a duty incumbent on everyone engaged in scientific labor, and on every one seeing hope in the scientific cult.

We had three meetings during the past year. The retiring President in the Annual address gave an able sketch of late progress in the production of organic compounds, and made suggestions for our future work which we have not yet attempted to energetically develop.

At our February meeting Mr. Walter H. Prest advocated a preliminary survey of Nova Scotian caves for possible natural history or anthropological remains. Your Council supplied him with some aid for such exploration, an account of the results of which will be presented by Mr. Prest himself at this meeting.

The May meeting brought out some valuable meteorological notes by Mr. F. W. W. Doane, C. E. ; a comparison of the monthly mean temperatures of Halifax and Plymouth on opposite sides of the Atlantic by our ex-President, Dr. Henry S. Poole, F. R. S. C., who does not forget the Institute, although absent from the Province; a sketch of Mineral Occurrences in the Granites at New Ross, Lunenburg County by Mr. A. L. McCallum, B. Sc. ; a paper on the effect of gravity on the concentration of solutions, by Mr.

Harold S. Davis, B. A.; and notes on fishes in Nova Scotia by our Secretary Mr. Harry Piers.

This is good work so far as a few members of the Institute are concerned. But more of us should have put new work on its records. Our publication funds and our magnificent exchange list, put us within the reach of privileges and advantages which I trust we may fully exploit during the present year.

Perhaps we should annually attempt at least one or two popular demonstrations of science applied to industries, the conservation of health, or the development of public utilities—something to interest the general public or to inspire the young student.

DEATH OF DR. R. W. ELLS.

We have to record with profound regret the loss during the year of one of our most useful and eminent members. By the passing away of the late Dr. Robert Wheelock Ells, LL. D., F. R. S. C., who died at the late residence on O'Connor street, Ottawa, early Tuesday morning, 23rd May, Canada loses one of her ablest scientists. Dr. Ells had been a member of the Geological Survey of Canada for nearly forty years, having joined the staff under Sir Wm. Logan, the founder of the survey.

The late Dr. Ells was descended from U. E. L. ancestors who came to Nova Scotia in 1761. He was born at Cornwallis, N. S., in 1845 and was educated at Horton Academy, at Acadia University and at McGill University from which he graduated in 1872 with first class honors and the Logan gold medal in geology, and natural history. He married in 1873, Miss Harriett N. Stevens of Onslow, N. S. Joining the staff of the Canadian Geological Survey in 1872, he has since been constantly engaged in geological work in that branch of the service.

He was also a prominent Fellow of the Royal Society of Canada, a Fellow of the American Geological Society, and a member of the Canadian Mining Institute. Besides being a past president of the Ottawa Literary and Scientific Society, Dr. Ells had also been president of the Ottawa Valley Graduates' Society of McGill University, and for a number of years past had held the position of representative Fellow for the province of Ontario

on the Corporation of McGill University. He had published numerous reports on the geology and mineral resources of the provinces of Nova Scotia, Prince Edward Island, New Brunswick and Quebec, as well as of the Northwest Territories and British Columbia. In addition he had written various papers for the Royal Society of Canada, the Geological Society of America, the American Institute of Mining Engineers, the Ottawa Field Naturalists Club, the Canadian Mining Institute and the Nova Scotia Mining Institute.

Dr. Ells was perhaps best known in recent years for his work in connection with the problem of the utilization of the oil shales of Eastern Canada. It was indeed largely through his efforts that attention was first called to the great value of these deposits and his memoir published in 1910 is the standard work on this subject.

From the year 1894 he has contributed many valuable geological papers to our Institute, which will be found in its Transactions.

Our duty is to endeavor to fill up our ranks with new men who will carry on, down the current of time, the good work which makes the past history of our Institute one of the most illustrious in Canada.

The Treasurer, MR. BOWMAN, presented his annual report, showing that the receipts for the year 1910-11 were $781.74, the expenditure $540.83, and the balance in current account on 1st November, 1911, was $240.91; while the reserve fund was $696.38, and the permanent endowment fund was $885.58. The report having been audited, was received and adopted.

The Librarian's report was presented by H. PIERS, showing that 1,810 books and pamphlets had been received by the Institute through its exchange-list during the year 1910; and 1,357 have been received during the first ten months of the present year (1911), viz. January to October, inclusive. The total number of books and pamphlets received by the Provincial Science Library (with which those of the Institute are incorporated) during the year 1910, was 3,421. The total number in the Science Library on 31st December, 1910, was 42,409. Of these, 32,397 belong to the Institute, and 10,012 to the Science Library proper. That is,

about 76 per cent. are the property of the former, and about 24 per cent. belong to the latter. 626 books were borrowed besides those consulted in the library. No binding or purchasing was done during the year, there being no grant available for the purpose. The report was received and adopted.

The following were elected officers for the ensuing year (1911-12) :

President,—WATSON L. BISHOP, *ex officio,* F. R. M. S.

1st Vice-President,—ALEXANDER HOWARD MacKAY, LL. D., F. R. S. C.

2nd Vice-President,—DONALD M. FERGUSON.

Treasurer,—MAYNARD BOWMAN, B. A.

Corresponding Secretary,—PROF. EBENEZER MACKAY, PH. D.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—PHILIP A. FREEMAN; PROFESSOR FREDERIC H. SEXTON, B. SC.; FRANCIS W. W. DOANE, C. E.; A. L. McCALLUM, B. SC.; PARKER R. COLPITT; H. JERMAIN MAUDE CREIGHTON, M. A., M. SC., DR. SC., F. C. S.; and PROFESSOR CLARENCE L. MOORE, M. A.

Auditors,—DONALD S. MacINTOSH, M. SC., and ALEXANDER McKAY, M. A.

The celebration of the fiftieth anniversary of the foundation of the Institute was discussed and referred to the council to take such action as it might think fit.

PROFESSOR MOORE suggested that some method be devised for cooperation work in obtaining data on biological questions in the province. The matter was referred to the council.

FIRST ORDINARY MEETING.

N. S. Technical College, Halifax; 13th November, 1911.

THE PRESIDENT, WATSON L. BISHOP, in the chair.

The ordinary meeting was held on the conclusion of the annual business meeting.

In the absence of the author, MR. PIERS read a "Report on Cave Exploration in Hants County, Nova Scotia," by WALTER HENRY

PREST, of Bedford, N. S., being the result of investigations under-taken by MR. PREST at the request of the council of the Institute. (See Transactions, p. 87). The subject was discussed by PROF. C. L. MOORE, PROF. E. A. HOLBROOKE, PROF. D. S. MACINTOSH, H. PIERS, and others.

SECOND ORDINARY MEETING.

N. S. Technical College, Halifax; 11th December, 1911.

THE FIRST VICE-PRESIDENT, DR. A. H. MACKAY, in the chair.

It was announced that PROFESSOR C. J. CONNOLLY, PH. D., department of biology, University of St. Francis Xavier, Antigonish, N. S., had been duly elected an associate member by the council on 5th November.

MR. PIERS drew attention to the desirability of collecting information regarding the economic and medicinal use of Nova Scotia plants among our Micmic Indians.

In the absence of the author the following paper was read by PROF. C. L. MOORE:—

SACRED PLANTS OF INDIA.—BY CAPTAIN J. H. BARBOUR, R. A. M. C., F. L. S., Nowgong, Central India.

In view of the supreme interest which will centre round India during this present year and culminating in December when His Majesty, the King, will visit the country to hold the great Delhi Durbar, there is certain to be a desire on the part of the many people who will visit the country, some for the first time, to learn before they come, as much about India, her history, customs and manners as they can in order to appreciate the magnificence and significance of this important event in her national life and also to create for themselves an interest in what they may see generally over the country.

There will be much travelling up and down the vast peninsula, and guide books, histories and other literature will be greatly in evidence to elucidate and explain points. There is, however, one subject which may appear insignificant compared with the others and yet it is one which will be very much to the fore wherever the traveller goes, I mean the plants of the country. He will see new

and strange varieties of plants from the time he lands in Bombay till the time he leaves India again, and he will see many which are sacred and associated with Indian religious thought to a very large degree, and hence I have endeavoured to try and write this article in the hopes that it may be a help and pleasure to many who may care to look upon them during their stay in the country, which in many cases will only be for a few weeks or so.

I often wonder how many think about the trees and plants they see when either on their railway journey or when visiting the shrines and temples of ancient India, about which are usually planted trees or plants of a certain kind; and yet the lives of the Hindus are intimtely woven both now and in the past with some of these plants; and the plants themselves, could they but speak, could tell wonderful tales of yore, when the Pantheon of Hindu deities was perhaps more in evidence than it is to-day. Yet to-day it is not by any means obliterated.   The old is still with us in India and the native has remained unchanged, except perhaps in the large cities for centuries.   Civilization and Western influences have, it is true, prevaded the large centres of the community; but away in the jungle villages, the villager still preserves his reverence for his ancestors' deities and his hopes in the sacredness of his faith and the associations which surround it, and amongst these the trees which form the subject of my article.   For these reasons I have thought that it may prove interesting to your readers to tell them something about these plants, what they are like, their uses either economically or medicinally, and their associations, so far as can be found out at the present day.   The writer has practically seen all the trees or plants to which he refers and so can speak from experience, both as to their uses and also their interesting points to a great extent. The object of this article being, however, not only to prove interesting, but useful to all who may be thinking of visiting India and wishing to know the native names of the trees, the names of the trees will be given, not only in the Latin form, but in the vernacular and English in each case.

Before proceeding to speak about these plants a word or two must be said on one or two of the chief deities to which these

plants are sacred, and the remainder will be grouped together and referred to as the plants are spoken of.

Let us take Vishnu first as he is the most popular of all Hindu deities in his various incarnations. He is the personification of nature's preserving powers. When the whole earth was covered with water he lay sleeping on a serpent, and while he slept, a lotus sprang from his navel and from it the great Brahma sprang the Hindu god existant. His heaven is on Mount Meru and his incarnations are ten.

Siva, the second and only other great deity I shall here refer to, represents the destructive power of nature, or perhaps I ought to say its transforming and reproducting power, and hence is of both terrible and pleasing dispositions. He is usually represented as a white man with five heads and a third eye in each head, and the heads are surmounted by a crescent moon, and the river Ganges flows, as it were, from his fifth head. His most usual image is, however, the "Linga" which is the sign of reproduction and which is exceedingly common on many temple steps. His heaven is Mount Kackasa.

These are the two chief deities to which most of these trees are sacred, but there are many more; and to these, trees and plants are also sacred. I shall first of all point out the plants sacred to these two deities and then grouping the others, refer to them together. I shall also say a few words about sacred trees which are sacred, as it were, for themselves alone and yet have no doubt a deeper idea beneath.

The following plants are sacred to Vishnu alone: *Ocymum sanctum.*

To Siva: *Aegle marmelos, Crataeva religiosa, Poinciana regia, Zizyphus jujuba, Jasmimum sambac, Gardenia lucida, Michelia Champaca, Ficus religiosa and Ficus Bengaliensis.*

To Siva and Vishnu together: *Jasmimum sambac, Artemisia vulgaris, Nerium odorum, Ixora coccinea, Origanum Marjoram.*

Ocymum sanctum, Vern. "Kalatulsi." Holy Basil. The only plant dedicated to Vishnu, and a most important one it is, though only an herb, erect, softly hairy, with ovate toothed leaves,

small corolla purple in colour. The fruit is reddish brown. Sometimes the plant is purple all over. It is cultivated very much round temples and in Brahmins' gardens, and is highly reverenced.

"Nothing on earth can equal the virtues of a Tulasi" has been quoted often. Puja (that is invocations) is offered to it daily. When a Brahmin is dying, one of the plants is brought and put on a pedestal and pujā is offered to it. A bit of the root is put into the mouth of the dying man, and its leaves are sprinkled over face, eyes, ears and chest. He is also sprinkled with a twig of it, dipped in water, from hand to foot. At the same time his friends say aloud "Tulasi, Tulasi, Tulasi"! and the man dies happy and goes straightway and certainly to Swarga. To obtain pardon for all one's sins, it is enough to look at this sacred plant. By touching it a man is purified of all his defects. Salvation is assured to any one who waters and tends it daily. A branch offered to Vishnu in milk will be more pleasing to the god than a thousand cows. A sprig of it dipped in saffron and offered to the god at any time ensures the person's enjoyment of Vishnu's happiness. To give a twig of it to anyone suffering cares and anxieties, ensures a certain means of securing for him a satisfactory ending to all his difficulties. It is much used in native medicine with a supposed excellent results. Its leaves have a sweet aromatic scent and the Brahmins use the plant as an aid to digestion after meals, and after ablutions to prevent getting chills, as it is supposed to have cordial-like effects.

Aegle marmelos, Vern. "Bel." Ball Fruit. A fairly large tree found every where in India and as common in some parts of the jungle as near villages and temples. Its thorns and its flowers are in panicles. The fruit is about the size of an orange, round and smooth with a pulpy interior; and when dried, the appearance is rather honey-combed. The fruit is a well known remedy for dysentery, and it is used a good deal. It is bitter, however. This tree is sacred to Siva.

Crataeva religiosa, Vern. "Warwan." Is found near many temples in Central India and Bengal. A tree with long petioled leaves and ovate leaflets. Flowers in racemes, white or buff with long purple filaments. Fruit large and round or oval. The leaves

are armomatic and are used in rheumatism, while the roots and bark are used in calculi.

Poinciana regia, Vern. "Sandesra." Gold Mohur tree. The most beautiful tree in India in my opinion, and its various names well become it, for it is indeed a queen of trees in its beautiful and graceful green symmetrical fan-like arrangement of branches and leaves which towards the end of the summer take the place of its golden flowers. The flowers are of old gold or striped with red, and the English name is the name of the only gold coin in India. Covered with flowers two or three inches in size across, the tree is indeed in May and June a veritable flame of gold and no description on paper can equal the gorgeous look of one of these trees in full bloom. Siva is highly honored in this tree.

Zizyphus jujuba, Vern. "Bhor." Jujube tree. Not a very large tree, but a thorny one with small ovate leaves, dark green on the upper surface and downy brown underneath. Flowers in cymes, strong smelling and small; fruit the size and colour of a yellow cherry. It is very common everywhere in the jungles, and it is thought to be, as well as being sacred to Siva, the Siora of the Koran, a tree which Mohammed in his miraculous night journey found growing at the further limit of the seventh heaven. The wood of the tree is poor, but the fruit is eaten raw, although it is bitter. Many a time have I seen the natives collecting them in abundance. It has mild medicinal properties as a blood purifier, but otherwise there is nothing striking about it, and one might easily pass the tree without noticing it.

Jasmimum sambac, Vern. "Mogri." Arabian Jasmine. A shrub with oval leaves and racemes of opposite white flowers. Fruit rather small, round, and black. One would always recognize this as a variety of jasmine, and it is appropriately associated with Siva in his reproductive energy, for the leaves are used as a lactifuge; the bruised leaves being applied to the breasts. It stops the secretion of milk in cases of threatened abscesses and hence women must bless Siva for having associated with him such a remedy.

Gardenia lucida, Vern. "Dekamali." English is Dikamali or Gardenia. A large shrub or small tree with smooth shiny oval

smooth leaves. Flowers white and it is often seen as an ornamental shrub in gardens. A strong smelling yellow gum exudes from its shoots and from this an ointment is made which is called by its Hindu name. This ointment I may add is used for foul ulcers and to keep flies off sores. The flower is rather a pretty one and is a valuable addition to the ornamental shrubs of the country.

Michela champaca, Vern. "Champaka." No English equivalent. A fair sized tree, more or less evergreen with long ovate pointed waved leaves. Flowers a delicate pale yellow and very fragrant. Fruit is a spike of carpels. It is a rather curious looking tree and gives, when the leaves are fully expanded, a good deal of shade. The wood is very soft and easily broken. The flowers are used by the native women as ornaments in their hair and are much offered in their temples to Siva. Shelley speaks of the tree thus:—

"The champak odours fall
Like sweet thoughts in a dream."

The pale yellow flowers have a sweet oppressive odour which is celebrated in Hindu poetry, and from the wood images are made of Buddha for temple uses.

Ficus religiosa, Vern. "Pipal." The Peepul tree or sacred fig. A large, smooth handsome tree, spreading somewhat, with leaves long and pointed much. It looks rather like a wide graceful poplar tree. Fruit is size of a black cherry. It is common over India, in the jungle and near temples and places of habitation. It has been known to live for 2000 years. It is found often near where Brahmins perform the ablutions, and the rustle of the leaves in a breeze has been compared to the sounds of a cithara. Under this tree Vishnu is supposed to have been born by some. No one is allowed to cut it down or lop off branches. Leaf-pulling is only allowed for acts of worship. Each tree springing from an unpreceived source is emblematical of the body which really springs from, and is one with the godhead. It is also said to typify the universe. Sometimes this tree is invested like a Brahmin with that great honor the "triple cord" which only Brahmins among the castes of India can aspire to. Sometimes it is solemnly married, as other trees and plants are to each other in India. In

the case of the Peepul tree, a Margosa tree (*Melia Azadirachia*) is usually chosen as its mate, or occasionally a plantain (*Musa*) Here and there one may on roadsides see a Peepul tree and a Margosa tree side by side in little mounds. This union is not accidental, but a true marriage union. They are wedded by actual ceremonies used for Brahmins and after a time it has been seen the branches of the two trees actually intertwine and their trunks are incorporated with each other.

Ficus Bengaliensis, Vern. "Wad." Banyan tree. A fine tree possession aeria roots, smooth bark, light greenish leaves, ovate and downy beneath, smooth and shining when old. Fruit, deep-red in colour, size of a cherry. Common in the plains and jungles and may grow to an immense size as the famous one in the Nerbudda Valley, Central Provinces of which Arnold speaks:—

> "Its ample shade
> Cloistered with columned drooping and roofed
> With vaults of glistering green."

With this tree also marriages are celebrated. A Palmyra palm may be seen apparently growing out of the trunk of a Banyan, but it is really the other way on, the palm being the older, the seeds of the Banyan being dropped in its fronds and throwing its roots to the ground. (Roxburgh).

We now come to the trees sacred to Vishnu and Siva together. I have already described the Jasmine and I pass on to the others.

Artemesia vulgaris, Vern. "Daona." Wormwood. A tall strong herbaceous plant, leaves pinnated or lobbed deeply, toothed and cut. Flowers in panicles, very small and florets yellowish. Bract, leafy or dry. An uninteresting plaint in my opinion from a purely botanical point of view. It is curious, however, to note that in Old Testament history it is associated with distress and calamity and possibly this association may also be seen in its association with the Hindu Siva, in his terrible embodiment. It is worthy of note that absinthe is made from some species of Arthemesia.

Nedium odorum, Vern. "Kanher." Oleander. A plant or shrub rather known in European conservatories and considered to

be very poisonous, even out here. It has beautiful red flowers and long linear lanceolate leaves.

Hooker thinks, "the willow of the brook" in Scripture to be the Oleander; and he states that wood, flowers and leaves are all very poisonous, but I have heard of its being used out in India, and I have read of fatal results. The resim is considered by natives to be useful in easing colic and stomachic pains and warming if taken internally; and externally, it is reputed to be antiseptic, but I have not yet been able to find out why! It is, however, mostly used internally in hysteria. It makes a very bright show when in full flower, its rosy red bloom being both delicate and graceful.

Ixora coccinea, Vern. "Bakora." Torch tree. A shrub with smooth obovate leaves, flowers bright scarlet in close umbels or corymbs, calyx minute, corolla lobes, broad pointed. It is rather like a geranium and is called also the "jungle geranium," and it is probably the Bandhuka of Sanskrit poetry.

Origanum Marjoram, Vern. "Marva." Majoram. A plant with no particular beauty, it contains a volatile oil which is used for different purposes and being aromatic in character is or has been used in temples because it gave fore a sweet smelling savor for the deities; and its medicinal properties also make it acceptable as a plant for the deities and for the native as well. Now besides the plants that are sacred to the deities already given, there are a number more which are sacred to other deities or groups of deities and the first of these is Kama or Kama Devi, the Hindu cupid or god of love. He is the son of Lakshmi and is represented similarly to the way cupid is at the present day, but he may ride on a red parrot or lory.

The plants sacred to him are: *Mesua Ferrea, Pandamus fascicularis, Mangifera Indica,* and *Michelia champaca* (already described).

Mesu Ferrea, Vern. "Nag Champa." Mesua. A beautiful tree sometimes growing sixty or seventy feet high with oblong lanceolate leaves, shining above and whitish beneath. Flowers, solitary or in pairs, large silvery white with bright yellow anthers. Fruit, oval and pointed. A tree which has been considered by

some as the most beautiful on earth and with blossoms of a delicately fragant odour, and fit indeed for Kame-Devis quiver. In Ceylon it is near every Buddhist temple and the flowers have been said to resemble white roses, while the shorts and buds of the tree are of deep crimson. The flowers also have been described as camellia-like in character and its foliage a mass of glossy green. Its timber is splendid, and Wordsworth's quotation matches it well:

> "A silver shield with boss of gold
> That spreads itself some fairy bold
> In fight to cover."

It yields an aromatic oleo-resim and the dead flowers are used as a fragrant adjunct for decoctions and oils.

Pandamus fascicularis, Vern. "Kevri." Screw-pine. A cactus-like shrub (there are no true indigmous cactuses in India) with long sword-shaped sharply toothed spinous leaves. The flowers look like innumerable filaments and grow on a spadix 3 or 4 inches long, inclosed in leaf-like bracts. Fruit nearly round, something like a pineapple. The tender white leaves of the flowers have a delightful fragrance. Roots are sent out from many parts of the stem and give the idea of the tree being propped up by them. It is the Kevada or Sanskrit poetry, and a perfumed oil is extracted from the flowers which is called 'Kevde.'

Mangifera Indica, Vern. "Amb." Mango tree. Smooth, leaves oblong and lanceolate. Flowers, small in greenish yellow panicles, fruit large and greenish and yellow, and varying somewhat in shape from oval to irregularly round. A fine tree which grows all over India and has been planted everywhere. The fruit is easily the finest Indian fruit and possesses a subtle and delicate flavour, its only disadvantage being its immense stone. It has the reputation that it must be eaten in one's bath on account of its difficulty to handle, but I have not found it necessary to go to such length to enjoy it. The tree when in full bloom and many together, is rather pretty, though individually the flowers are modest. The smell of the flowers by night when out driving along the jungle roads is rather strong and some think them oppressive. The best ones are the Bombay Mangoes, famous all the world over. Every village temple or shrine is well planted with

them, for they afford good shade as well as a most nourishing fruit. The unripe fruits are made into sherbets, pickles, chutnies. The stone or kernel contains tannic acid and turpentine and the pulp of the ripe fruit gallic acid, and gum in traces. The Am Chur which is very popular amongst Indian native troops is a valuable anti-scorbutic. This form of the fruit is that of the green mangoes dried, skinned and stoned, cut into pieces. Half an ounce of this is said to be equal to an ounce of good lime juice. Mango food is a favorite diet with Europeans, just as gooseberry food is at home, and in my opinion it has a very strong resemblance in flavour.

I now come to the plants sacred to the Hosts of Heaven, by which we mean the nine regents of the planets and eclipses, and these give their names to the days of the week, and I give them as they may prove interesting to readers of the article generally.

Rair, the sun regent, Sunday. Soma, the regent of the moon, Monday. Mangala, Tuesday. Buda, regent of Mercury, the author of a hymn in the Rig-veda, Wednesday. Brihapati, Thursday. Sukra, Friday. Sani, Saturday. Rahu and Ketu, eclipses.

To these Hosts of Heaven are sacred the:

Hibiscus Rosa-Sinensis, Butea frondosa, Acacia Catechu, Ficus religiosa (already described), *Ficus glomeratus, Poa cynosuroides.*

Hibiscus Rosa-Sinensis, Vern. "Jasud." Shoe flower. The different varieties of Hibiscus are numerous in India and form beautiful shrubs and useful vegetables, and all are more or less formed on one type, that of a variety of mallow, to which natural order they belong. The above is probably better known as the China rose and is common in gardens in India and I believe is to be found in different parts of America and elsewhere, and so will be more or less generally known to your readers It is a rather pretty plant and the flowers are used in various disorders But I wonder if anyone of your readers know that an oil is made by mixing the juice of the fresh petals with olive oil in equal parts and boiling till the water is evaporated is useful as a stimulating application to the hair. Possibly some ladies may care to know of a new hair wash or a hair producer. Anyhow the natives out

here believe it to be useful and it seems to me to be a very simple preparation.

Butea frondosa, Vern. "Pallas.' The bastard teak. The vernacular name of this tree is taken from the famous field of Plassy on which our fortunes in India so much depended. It is a common jungle tree in early spring and when in flower is covered with beautiful scarlet-orange flowers which make a wondrous colour effect. Hence its fancy names "flame of the forest," and "pride of the jungle," which nearly all Anglo-Indians know it by. Seen closely the individual flowers are much the same colour, but the calyces which are of a very deep greenish-brown, and exactly like velvet, throws the scarlet into showy relief, and as the flowers are in panicles the effect is more striking still.

The bark of the tree contains a gum, which is full of tannic and gallic acids. The gum and flower juice is used for making dyes. The bark is used for snake-bites.

It is indeed a flower which
> "With a scarlet gleam
> Cover a hundred leagues, and seem
> To set the hills on fire."

Acacia Suma, Vern. "Khair." Catechu. A small tree with white bark, thorny, leaves compound, leflets 30 to 50 pairs, flowers white, pod strap-like. A well known rather delicate tree, but not a particularly interesting one to look upon. Catechu, its English name, is an extract from this tree, and is so well known that no coments are necessary on it. Its chief use in India is that it is one of the ingredients of the packet of Betel leaves chewed by the natives, which I suppose is one of the common things one notices travelling through the country any where. Be it remembered, however, that this packet, however objectionable it may be to us and however discolouring to the mouth and lips, contains several useful ingredients which probably make life more agreeable to the native and certainly in some cases staves off sickness, colic, etc.

Kath-Bol is a mixture of catechu and myrrh given to women after confinement as a tonic and to induce a flow of milk.

Ficus glomerata, Vern. "Gular." The Gular fig. A large tree with leaves oblong or broadly lanceolate, fruit in clusters on the trunk or branches, small, red downy. The wood is a fair timber, and the fruit is edible. A bath made of the fruit and bark with water is regarded as a cure for leprosy. The liquid extract from the root is used as a tonic from the Vaidvans. It is a fairly common tree over the country and may often be recognized quickly by the growth of galls on its leaves.

Poa cynosuroides, Vern. "Kust." Dharba grass. This is not a grass as its name suggests, but belongs to the natural order, Boraginaceae, and grows on damp marshy swamps.

Brahmins always keep it in their houses and it is used in all ceremonies, including sacrifices.

It grows to a height of two feet and has a finely pointed top and is rough to the touch.

There are several legends regarding the origin of this sacred plant. One, that it was produced at a time when gods and giants were all busy churning with the mountains of Mandara, the Sea of Milk in order to extract from it Amrita or nectar which would render them all immortal. The story goes on to say that while the mountain was rolling about on Vishnu's back, who in the form of a turtle was supporting it, it rubbed off a great many hairs from the god, and that these hairs cast ashore by the waves, took root there and became Dharba grass. One wonders where the hairs on a turtle's back are, but this is a legend. Another legend is that while the gods were greedily drinking the nectar which they had extracted from the Sea of Milk, let fall some drops on the ground among ordinary grass which thus became sacred and grew up as Dharba grass .

Dharba grass although sacred to the hosts of Heaven is also considered to be part of Vishnu himself, and Brahmins worship it, and in their ceremonies use it, believing that it has the virtue of purifying everything. An annual feast is instituted in honor of it on 8th day of the Moon in the month of Badra (September). and is called Dharba-ashtami. By offering the grass as a sacrifice on that day immortality and blessedness for ten ancestors may be assured. Another result is that one's posterity is increased and

multiplied like Dharba grass which is one of the most prolific plants in the vegetable kingdom.

We have still another set of sacred trees which are sacred to the nine forms of Kali. The Kali represented in India in ancient days the same as the old Roman patricians and refer to the ghosts or shades of ancestors. It will be noticed that some of those plants which are referable to deities are also to these spirits, such as *Aegle marmelos, Ocymum,* etc. But there are certain of special ones also, *Musa sapientium, Curcuma longa, Saraca Indica, Punica granatum.*

Musa sapientium, Vern. "Khela." The cultivated plantain. Its appearance is now probably well known all the world over now-a-days, and need hardly be described. Its specific name conveys an allusion to one of Theopharastus' statements concerning a fruit which served as food for the wise men of India, supposed to have been the plaintain.

It is worshipped by the Hindu woman on the 4th of Kartik Shudh in order that their husbands may survive them. Bunches the fruit are used in festivals and ceremonies, and are placed at the entrances to their houses on such occasions, especially at marriages, as appropriate emblems of plenty and fertility.

Some people consider it to have been the forbidden fruit of Eden and again that it was the grape of the Promised Land.

Curcuma longa, Vern. "Haldi." Twemerie. Herbaceous. The leaves are long, broad and lanceolate, the leafy stem is four to five feet high. The flowering bracts pale green and the coma a beautiful pink. The plant is known in Bombay by its Hebrew name "Karkam," and it was evidently known in England as early 1710 or earlier. The uses of twemerie are well known, and I only intend to say that the oil is used by the natives in small-pox and chicken-pox. The rubbing of the oil is an essential part of Hindu wedding ceremonies and the root enters into many religious ones. By the root, I mean tuber underground. Mixed with lime, it forms the liquid used in the Arati ceremony of warding off the "evil eye." With lime juice, the Hindus of the sect of Vishnu prepare their yellow Tiruchurnum, with which they make the

peculiar mark on their forehead. Visitors to India must often have seen the numerous marks of different sects and castes.

Punica granatum, Vern. "Anar." The Pomegranate. It is sufficiently well known with its scarlet orange flowers and avidulated fruit to need no description. It grows well in other parts of Asia and Greece as well as India, where it was and is held sacred and symbolic of fructification and procreation and also death and resurrection.

Giotto placed a pomegranite in the hands of Dante, and Raphael crowned Theology with blossoms of its flowers.

In the old testament it is referred to, and it is seen in Assyrian and Egyption sculpture. In India it has often been referred to by Sanskrit writers, and has been seen in its sculpture. Several alkaloids are obtained from various parts of the plant and also organic acids and mannite.

Saraca Indica, Vern. "Ashoka." The Asoka tree. A small tree belonging to the Leguminoseae, but unlike the usual type, it hardly looks like a flower of this order. The flowers are orange, changing to red in large round heads with long stamens. The pod is broad, flat or scimitar shaped. It is a beautiful sight to see when in full bloom, and its soft Hindu name occurs frequently in old Indian poems. The flowers are used in temple decorations and as a symbol of love is also dedicated to Kama. It possesses a certain charm in preserving chastity and it is also a tree of refuge, as in the legend of Buddha, when Maya is conscious of having conceived the Buddis-Attya, she retires to a wood of Asoka and sends to her husband.

The tree is also held sacred by the Burmans as under it Gaudama was supposed to have been born.

It is much used by native physicians in womb affections, the bark being mixed with milk and made into the form of a decoction. Asoka Grita is made from the bark and clarified butter to which some aromatic herbs are added.

There are a few other plants which are held sacred, but which I must omit from this article if I am to endeavour to keep it within reasonable limits. The ones I have told something about are important and fairly common ones, and the writer

trusts they may prove interesting, both to those who have had a tour through India and to those who intend coming, and serve as a sort of brief popular botanical and folk-lore appendix to guide-books which may not touch upon this part of sight-seeing in detail.

The foregoing paper was discussed by H PIERS, F. W. W. DOANE, DR. A. H. MacKAY, PROF. MOORE, and D. M. FERGUSON; and a vote of thanks was passed to DR. BARBOUR for his interesting paper, on motion of Messrs. Piers and McCallum.

THIRD ORDINARY MEETING.

N. S. Technical College, Halifax; 8th January, 1912.

THE PRESIDENT, WATSON L. BISHOP, in the chair.

It was announced that CAPTAIN J. H. BARBOUR, Royal Army Medical Corps, F. L. S., of Jabalpur, C. P., India, had been duly elected a corresponding member by the council on 28th December.

HARRY PIERS, curator of the Provincial Museum, Halifax, read a paper entitled "Brief Account of the Micmic Indians of Nova Scotia, and their Remains," the subject being illustrated by a typical set of specimens of their ancient and modern implements, customs, etc. (See Transactions, p. 99).   The paper was discussed by the PRESIDENT, DR. A. H. MacKAY, DR. E. MACKAY, DR. A. STANLEY MACKENZIE, D. M. FERGUSON and WILLIAM McKERRON.

FOURTH ORDINARY MEETING.

THE FIRST VICE-PRESIDENT, DR. A. H. MacKAY, in the chair.

H. JERMAIN MAUDE CREIGHTON, M. A., M. SC. DR. SC., F. C. S., lecturer on physical chemistry, Dalhousie University, Halifax, read a paper on "The Optical Activation of Racemic Bromcamphor Carboxylic Acid by means of Catalysts: the Specificity of Catalysts." (See Transactions, p. 1).   The subject was discussed by PROF. E. MACKAY, DR. A. H. MacKAY, D. M. FERGUSON, and PROFESSORS BRONSON, MACINTOSH and HARRIS.

FIFTH ORDINARY MEETING.

N. S. Technical College, Halifax; 11th March, 1912.

THE PRESIDENT, WATSON L. BISHOP, in the chair.

It was announced that DAVID FRASER HARRIS, M. D. C. M., D. Sc., B. Sc. (Lond.), F. R. S. E., Professor of physiology and histology, Dalhousie University, had been elected an ordinary member by the council on 29th February.

HAROLD S. DAVIS, B. A., Instructor in physics, Dalhousie University, Halifax, read a paper on "The Conductivity of an Aromatic Base in Water and certain Organic Solvents." (See Transactions, p. 40). The subject was discussed by DR. H. J. M. CREIGHTON and PROF. E. MACKAY.

H. JERMAIN MAUDE CREIGHTON, M. A., M. Sc., DR. Sc., F. C. S., lecturer on physical chemistry, Dalhousie University, Halifax, read a paper on "The Behavior of Iron Salts, in the presence of Egg Albumen and other Organic Substances, towards certain Reagents." (See Transactions, p. 61). The subject was discussed by C. B. NICKERSON, PROF. E. MACKAY, DR. A. H. MACKAY, and D. M. FERGUSON.

SIXTH ORDINARY MEETING.

N. S. Technical College, Halifax; 9th April, 1912.

THE SECOND VICE-PRESIDENT, D. M. FERGUSON, in the chair.

In the absence of the author, MR. PIERS read a paper by LAWRENCE W. WATSON, M. A., Charlottetown, P. E. I., on "The Geological Age of Prince Edward Island." (See Transactions, p. 145). The paper was discussed by R. H. BROWN, H. PIERS, and others; and a vote of thanks was passed to MR. WATSON.

C. B. NICKERSON, M. A., Demonstrator in chemistry, Dalhousie University, Halifax, read a paper on "The Qualitative Separation of Metals of the Iron Group; a New Method for the Removal of PO_4''' Ions." (See Transactions, p. 95). The subject was discussed by DR. H. J. M. CREIGHTON.

DAVID FRASER HARRIS, M. D., D. Sc., B. Sc. (Lond.), F. R. S. E., Professor of physiology and histology, Dalhousie University, Halifax, read a paper entitled, "On the Intimate Associations of

Inorganic Ions with Native and Derived Proteins." (See Transactions, p. 76). The paper was discussed by Dr. Creighton, L. C. Harlow, and D. M. Ferguson.

SEVENTH ORDINARY MEETING.

The President, Watson L. Bishop, in the chair.

Mr. Piers reported that the council had under consideration the celebration of the fiftieth anniversary of the foundation of the Institute in December, 1862, the celebration to take place in December of this year, and that a committee had been appointed to deal with the matter and to report to the council, and that this committee would be glad to consider any suggestions from the members in general.

The Second Vice-President, D. M. Ferguson, took the chair, while the President, Watson L. Bishop, read a paper on "The Canada Grouse (*Dendragapus canadensis*) in Captivity: its food, habits, etc." (See Transactions, p. 150). The subject was discussed by H. Piers.

J. H. L. Johnstone, B. Sc., Demonstrator in physics, Dalhousie University, Halifax, read a paper on "The Electrical Resistance and Temperature Coefficient of Ice." (See Transactions, p. 126). The paper was discussed by Dr. Creighton, and a vote of thanks was presented to Mr. Johnstone.

A paper by A. H. MacKay, Ll. D., F. R. S. C., superintendent of education, on "Phenological Observations in Nova Scotia, 1911," was read by title. (See Transactions, p. 175).

Harry Piers, curator of the Provincial Museum, read a paper on "Mastodon Remains in Nova Scotia." (See Transactions, p. 163). The subject was discussed by D. M. Ferguson.

A paper by H. Jermain Maude Creighton, M. A., M. Sc., Dr. Sc., F. C. S., lecturer on physical chemistry, Dalhousie University, Halifax, "On the Electrical Conductivity of Acetophenone Solutions of certain Alkaloids and other Organic Bases," was read by title. (See Transactions, p. 154).

Harry Piers,
Recording Secretary.

PROCEEDINGS

Nova Scotian Institute of Science.

SESSION OF 1912-13.

ANNUAL BUSINESS MEETING.

Civil Engineering Lecture Room, Technical College,
Halifax, 11th November, 1912.

The President, Watson L. Bishop, in the chair.

Active members present: Dr. A. H. MacKay, Donald M. Fergusson, M. Bowman, Prof. E. Mackay, A. L. McCallum, Prof. C. L. Moore, D. S. McIntosh, Prof. A. S. MacKenzie, Prof. H. L. Bronson, Prof. D. Fraser Harris, C. B. Nickerson, R. H. Brown, W. McKerron, A. J. Barnes and H. Piers.

In the absence of a presidential address, the Corresponding Secretary (Prof. E. Mackay) presented a report on the work of the Institute during the past year, and suggesting lines of work that might be taken up in the future.

The Treasurer, M. BOWMAN, presented his annual report, showing that the receipts for the year ending 31st October, 1912, were $809.91, the expenditures $241.48, and the balance in current account was $568.43; while the reserve fund was $708.51, and the permanent endowment fund, $912.13. The report, having been audited, was received and adopted.

The Librarian's report was presented by H. PIERS, showing that 1,688 books and pamphlets had been received by

the Institute through its exchange list during the year 1911; and 1,298 have been received during the first ten months of the present year, 1912, viz. January to October inclusive. The total number of books and pamphlets received by the Provincial Science Library (with which those of the Institute are incorporated) during the year 1911, was 3,088. The total number in the Science Library on 31st December, 1911, was 45,497. Of these, 34,085 (about 75 per cent.) belong to the Institute, and 11,412 to the Science Library proper. Six hundred and forty-two books were borrowed, besides those consulted in the library. It was again reported that no binding or purchasing was done during the year, there being no grant for the library's support. The report was received and adopted.

Dr. A. S. MacKenzie and others spoke of the great need of having the volumes bound in the library, and it was agreed that some action should be taken in the matter.

The following question was then discussed: Whether the Institute shall offer money grants, when needed, to scientific research students, to assist in furnishing necessary apparatus, etc.; it having been suggested that two grants might be offered of $50.00 each and four of $25.00 each.

The subject was discussed by Dr. Fraser Harris, Dr. MacKenzie, Dr. A. H. MacKay, Dr. E. Mackay, and Mr. Piers.

On motion of Dr. E. Mackay and Prof. Bronson, it was resolved that the Council of the Institute be empowered to expend, at its discretion, a sum not to exceed fifty dollars to aid scientific research.

The consideration of the celebration of the Fiftieth Anniversary of the Foundation of the Institute, was referred back to the Council.

It was announced that Albert Johnstone Barnes, service inspector, Maritime Telegraph and Telephone Co.,

Halifax, had been duly elected an ordinary member on 4th October last.

FRANK WILLIAM DODD, Assoc. Mem. I. C. E., of Brooklyn, N. Y., and Weymouth, England, gave an address on "Integral Atomic Weights," in which he advanced a new theory on the subject. (See Transactions, page 216.) The subject was discussed by PROF. E. MACKAY, PROF. BRONSON, DR. A. H. MacKAY, and PROF. A. S. MACKENZIE, and a vote of thanks was presented to the lecturer.

The following were elected officers for the ensuing year (1912-13):

President,—DONALD MacEACHERN FERGUSSON, F. C. S., *ex officio* F. R. M. S.

1st Vice President,—ALEXANDER HOWARD MacKAY, LL. D., F. R. S. C.

2nd Vice President,—PROFESSOR HOWARD LOGAN BRONSON, PH. D.

Treasurer,—MAYNARD BOWMAN, B. A.

Corresponding Secretary,—PROFESSOR EBENEZER MACKAY, PH. D.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—PARKER R. COLPITT; PROFESSOR CLARENCE L. MOORE, M. A.; ALEXANDER McKAY, M. A.; PROFESSOR DAVID FRASER HARRIS, M. D., C. M., D. Sc., B. Sc. (Lond.), F. R. S. E.; DONALD SUTHERLAND McINTOSH, B. A., M. Sc.; CARLETON BELL NICKERSON, M. A.; and WATSON LENLEY BISHOP.

Auditors—GEORGE B. BANCROFT, B. A., and WILLIAM McKERRON.

On motion of MR. PIERS and PROF. MACKAY a vote of thanks was presented to the retiring president, MR. BISHOP.

The Proceedings and Transactions, vol. xiii, part 2, were distributed.

First Ordinary Meeting.

Civil Engineering Lecture Room, N. S. Technical College,
Halifax; 9th December, 1912.

The First Vice President, Dr. A. H. MacKay, in the chair.

It was announced that J. H. L. Johnstone, demonstrator of physics, Dalhousie University, Halifax, had been duly elected an ordinary member.

Harry Piers, curator of the Provincial Museum, Halifax, read a paper on "The Occurrence of European Birds in Nova Scotia," and exhibited a specimen of the European Widgeon recently taken here. (See Transactions, page 228.)

Watson L. Bishop read a paper entitled "A Curious Lightning Freak." (See page 240.) The subject was discussed by the Chairman, Mr. Piers, Mr. Colpitt, Prof. Bronson, Mr. Barnes, and Prof. Fraser Harris, some of whom gave accounts of remarkable lightning effects as observed by themselves.

On motion of Prof. Mackay and Mr. Nickerson it was resolved that the Recording Secretary be requested to prepare for the Transactions a sketch of the history of the Institute during the past fifty years, with biographical notes on those who had assisted materially in its work.

Second Ordinary Meeting.

[Commemoration Meeting, 1862-1912.]

Civil Engineering Lecture Room, N. S. Technical College,
Halifax; Monday, 20th January, 1913.

The Nova Scotian Institute of Science met at 8 p. m. to commemorate the completion of half a century's work of the society, which had been organized at Halifax on the 31st

of December, 1862, as the successor of the Nova Scotian Literary and Scientific Society and the older Halifax Mechanics' Institute (1831).

The chair was occupied by the PRESIDENT, DONALD M. FERGUSSON, F. C. S., *ex officio* F. R. M. S. Other members present were: A. H. MACKAY, LL. D., F. R. S. C., first vice-president; PROF. EBENEZER MACKAY, PH. D., corresponding secretary; HARRY PIERS, recording secretary; and PROF. D. FRASER HARRIS, M. D., C. M., D. SC., F. R. S. E.; DONALD S. MCINTOSH, M. SC.; CARLETON B. NICKERSON, M. A.; and WATSON L. BISHOP, members of council; WILLIAM MCKERRON, auditor; and W. C. STAPLETON and J. H. L. JOHNSTONE, ordinary members.

The President announced the special purpose for which the meeting had been called.

There was read a paper by PROF. DAVID FRASER HARRIS, M. D., C. M., D. SC., F. R. S. E., of Dalhousie University, entitled " A Note on a Gastrolith found in a Moose." (See Transactions, page 242.) The subject was discussed by DR. A. H. MACKAY, H. PIERS, and others.

The RECORDING SECRETARY, HARRY PIERS, read a paper which he had prepared at the request of the society, entitled "A Brief Historical Account of the Nova Scotian Institute of Science, and the events leading up to its establishment; with Biographical Notes on some of those who have been prominent in its affairs." (See page liii.) Owing to lack of time, the presention of the biographical section of the paper was deferred to the next meeting. Remarks on the subject of the paper were made by the PRESIDENT, DR. A. H. MACKAY, DR. E. MACKAY, and others; and on motion of DRS. A. H. and E. MACKAY a vote of thanks was presented to MR. PIERS.

Attention was drawn to the fact that GENERAL CAMPBELL HARDY was the sole-surviving original member of the society,

and on motion of H. PIERS and DR. A. H. MACKAY, it was unanimously

"Resolved that the Nova Scotian Institute of Science, on the occasion of its meeting to commemorate the completion of half a century's work in the field of science in Nova Scotia, extends its hearty congratulations to its sole-surviving original member and former vice-president, MAJOR-GENERAL CAMPBELL HARDY, R. A., of Dover, England, the talented author of 'Forest Life in Acadie,' and that it furthermore expresses its high appreciation of his work for it in the past, and of his continued interest in all of its affairs; and that a copy of this resolution be forwarded to General Hardy."

THIRD ORDINARY MEETING.

Civil Engineering Lecture Room, N. S. Technical College, Halifax; 10th Febrdury, 1913.

THE PRESIDENT, D. M. FERGUSSON, in the chair.

The following telegram from the HONORARY SECRETARY OF THE ROYAL SOCIETY OF CANADA, dated at Ottawa, 20th January, 1913, and received the day after the commemoration meeting, was read by the Recording Secretary:

"Harry Piers, Nova Scotian Institute of Science, Halifax. The Royal Society of Canada congratulates the Nova Scotian Institute of Science upon the completion of a half century of endeavour. Most hearty wishes for continued usefulness and success.—DUNCAN SCOTT."

THE RECORDING SECRETARY stated that he had forwarded a due acknowledgment of the message to Mr. Scott.

An interesting letter from GENERAL CAMPBELL HARDY, our sole-surviving original member, dated at Dover, 20th January, was read, thanking the Institute for the cablegram sent to him on the occasion of the commemoration meeting, and giving reminiscences of the establishment of the society, etc.

The RECORDING SECRETARY, HARRY PIERS, presented a series of "Biographical Sketches of the Deceased Presidents and other Prominent Members of the N. S. Institute of Science since 1862," being the concluding section of an historical account of the society, the first portion of which had been read at the last meeting. (See page lxxxii.)

Discussion took place as to the ways in which more interest in natural history and science in general might be aroused among the people of the province.

FOURTH ORDINARY MEETING.

Assembly Room, N. S. Technical College,
Halifax; 4th April, 1913.

THE PRESIDENT, D. M. FERGUSSON, in the chair.

DAVID FRASER HARRIS, M. D., C. M., D. Sc., B. Sc. (Lond.), F. R. S. E., professor of physiology, Dalhousie University, Halifax, read a paper entitled, "Ventilation: its Discovery and Discoverer, and its bearing upon Tuberculosis," with lantern illustrations. The lecture dealt with the life and work of the Rev. Stephen Hales, D. D., F. R. S., 1677-1761, the inventor of ventilators (first described in 1743) which have had a most remarkable effect in lessening diseases. On motion of H. N. PAINT and M. THEAKSTON, a vote of thanks was presented to Dr. Harris for his lecture.

FIFTH ORDINARY MEETING.

Civil Engineering Lecture Room, N. S. Technical College,
Halifax, 12th May, 1913.

THE PRESIDENT, D. M. FERGUSSON, in the chair.

DR. A. H. MACKAY was appointed delegate to represent the Institute at the forthcoming meeting of the Royal Society of Canada.

The appointment of a representative to attend the fiftieth annual meeting of the Entomological Society of Ontario, to be held at Guelph, Ontario, on 27th to 29th August next, was left to the President and the Secretary.

DONALD SUTHERLAND McINTOSH, M. Sc., instructor in geology and mineralogy, Dalhousie University, Halifax, read a paper entitled, "Notes on a Granite Contact Zone near Halifax, N. S." (See Transactions, page 244.) The subject was discussed by W. H. PREST, H. PIERS, and others.

A paper by FRANK HENRY REID, M. D., C. M., SS. "Crispin," China Mutual Navigation Co., Liverpool, England, entitled "The Irregularity in the Occurrence of Secondary Sexual Colours, and deductions therefrom," was read by title, owing to the lateness of the hour; as was also one by A. H. MACKAY, LL. D., F. R. S. C., on "Phenological Observations in Nova Scotia, 1912." (See Transactions, page 250.)

HARRY PIERS,
Recording Secretary.

A Brief Historical Account of the Nova Scotian Institute of Science, and the events leading up to its formation; with Biographical Sketches of its Deceased Presidents and other Prominent Members. —By Harry Piers, Curator of the Provincial Museum, Halifax.

(Read at Commemoration Meeting, 20th January, 1913.)

Pioneer Naturalists.

No backward glance at the progress of scientific affairs in Nova Scotia would be at all complete without some reference to the pioneer workers in the field, the men who collected and observed, and thought and wrote, or otherwise laboured without the inspiring presence in their midst of institutions of learning and research, and companions of similar tastes.

The names we meet in this period are not many; but, *ipso facto*, something akin to a halo must surround them because these men were the Fathers of Science in this province.

Passing by the early voyagers and settlers, whose occasional hap-hazard observations on natural history are mostly of mere historic interest, we find that the close study of that subject seems to have begun about 1800 with Titus Smith, a man who was remarkable in many ways. He was followed by MacCulloch, Gesner, Webster, Brown and others, of whom I will give a few particulars.

Titus Smith, botanist, etc., was born at Granby, Mass., 4th September, 1768, and died at the Dutch Village, near Halifax, 4th January, 1850. He came to Nova Scotia with his father, a Yale graduate, in 1785, and settled at Preston, near Dartmouth, removing to the Dutch Village about 1800. He was remarkably well read and most accurate in his knowledge of many subjects, and became well known to all of his day as "The Dutch Village Philosopher." He was a most

enthusiastic student of botany, collected and observed all over the province, and conveyed the information he gained to the prominent botanists of the time in England, Scotland, France and elsewhere. He was also interested in geology, and in fact in natural history in general, as well as in the most improved methods of agriculture. As a general naturalist he was in advance of any others of his time in Nova Scotia, and his ability to read readily in various languages, placed scientific literature within his easy reach. In local history he was an acknowledged authority. About 1801-2 he was employed by the government to make a general tour or survey of the unsettled regions of the province, on which he left a voluminous manuscript report, including an account of our trees. Land surveying he took up as a profession. Unfortunately he published almost nothing over his own name, being of an exceedingly modest and retiring disposition; but he gave most liberally of his information to others and often wrote anonymously for the local press. The descriptive text of the first issues of Miss Maria Morris's superb "Wild Flowers of Nova Scotia" (about 1840) was written by him, and he collected the plants which that talented artist portrayed. His evidence before the Durham Commission of 1843 shows his extensive knowledge of the province. He contributed articles to the local press on the subjects of agriculture, rural economy, education, chemistry, geology and botany, and occasionally lectured before the Mechanics' Institute. For many years he was secretary of the Central Board of Agriculture and for a time conducted an agricultural periodical. Murdoch says of him that he was remarkable for the vast and varied information he acquired in botany, natural history, etc., and that with a knowledge of most that nature and books can teach, he united an unfeigned simplicity and kindness to the lowest as well as to the highest in the land, recognizing no distinction of rank whatever. On one occasion this Institute made a pilgrimage to his grave in the

woods near the Three-mile House, which will be found described in our Transactions. (See Lawson, M. J. K., History of Dartmouth, pp. 205-218; Trans. N. S. I. N. S., vol. i, pt. 4, pp. 149-152).

REV. THOMAS MACCULLOCH, D. D., ornithologist, was born at Neilston, Scotland, in 1776, and died at Halifax, N. S., 10th September, 1843. He was educated at the University of Glasgow and at Whiteburn, came to Nova Scotia in November, 1803, and was appointed first minister of Prince St. Church, Pictou, 6th June, 1804. From 1817 to 1824 he was the first principal of Pictou Academy, and in 1838 was appointed principal of Dalhousie College, Halifax. He made a study of our natural history, being particularly interested in birds, but also gave attention to mineralogy and left a manuscript list of Nova Scotian mineral localities which has since been published by this Institute. Audubon has left an account of meeting him in August, 1833 (See Audubon's Journal). MacCulloch's collection of birds is now the property of Dalhousie University, and, although badly mounted, contains some rare specimens, such as that of the Labrador Duck. Regarding the MacCulloch collection, it may be noted that Audubon says, "I am much surprised that his valuable collection had not been purchased by the governor of the province, to whom he offered it for five hundred pounds. I think it worth a thousand pounds." I can only add my own deep regret that the province did not obtain it for the price asked. About £500 has since been refused for one of its specimens alone!

ABRAHAM GESNER, M. D., F. G. S., mineralogist and geologist, was born at Cornwallis, N. S., of New York (loyalist) stock, on 2nd May, 1797, and died at Halifax, 29th April, 1864. He studied surgery and medicine in London under Sir Astley Cooper and Dr. Abernethy, and then returned to Nova Scotia, settling at Parrsborough. That district was rich in interesting minerals and he soon became

an industrious collector.   In 1836 he published his well-known
"Remarks on the Geology and Mineralogy of Nova Scotia"
which immediately brought him into notice.   It was par-
ticularly full in its observations on the trap district of the
Bay of Fundy.   From about 1838 till about 1843-4 he was
provincial geologist of New Brunswick, and established at
St. John the Gesner Museum, afterwards purchased by the
Natural History Society of New Brunswick.   Returning to
Cornwallis, he wrote "New Brunswick, with notes for Emi-
grants" and "Industrial Resources of Nova Scotia".   In
1850 he removed to Sackville, N. B., and in 1852 to Halifax.
Two years later he patented a process for extracting an
illuminating oil from coal and other bituminous substances,
which he at first called 'keroselene,' a name subsequently
shortened to kerosene.   After 1855 he devoted much of his
time to the production of kerosene oil, lived in the United
States, and published in 1861 his 'Coal, Petroleum and other
Distilled Oils'.   He finally returned to Halifax in 1863.
He was a fellow of the Geological Society of London (1840),
corresponding member of the Royal Geographical Society of
Cornwell and of the Academy of Natural Sciences of Phila-
delphia, and member of the Georgraphical Society of New
York.   He and Webster were the first students of science who
had been born in the province.   [See Gesner, A. T.: Gesner
Family of New York and Nova Scotia, Middletown, Conn.,
1912, pp. 11-13; Gesner, G. W.: Dr. Abraham Gesner, a
biographical sketch: Bulletin of the Nat. Hist. Soc. of
New Brunswick, vol. xiv, (1896), pp. 1-11, with portrait;
Matthew, G. F.: Abraham Gesner, a review of his scientific
work: Bull. Nat. Hist. Soc. New Brunswick, vol. xv (1897)
pp. 3-48.]

WILLIAM BENNET WEBSTER, M. D., M. P. P., mineral-
ogist, a man of lesser scientific note, was born at Kentville,
N. S., 18th January, 1798, and died at Halifax, 4th April,
1861.   Like Gesner he gave his spare moments to col-

lecting and studying our minerals, particularly those of the trap district, of which he formed a large collection of choice specimens which his widow presented to the Provincial Museum. He was the discoverer of the interesting fossil which Dawson named *Dictyonema websteri* in compliment to him. He was member of Assembly for Kings County, and is reported to have been a Fellow of the Geological Society, but this I doubt.*

RICHARD BROWN, geologist and mining engineer, was born at Lowther, Westmorland, England, on 2nd May, 1805, and died at London, 30th October, 1882. After experience in the coal-mines of his native country, he came to Nova Scotia in 1826 to report on and open up collieries in Cape Breton for Messrs. Rundell, Bridge and Co., and the newly organized General Mining Association, having been recommended for the work by the then Earl of Lonsdale. He began operating the Association's mines on 1st January, 1827. Subsequently he went to England, and then was stationed at Halifax till about 1839 when he returned to Cape Breton and was agent and general manager of this Association at Sydney Mines, with jurisdiction extending also to the Albion Mines in Pictou County, till his final departure for England on 1st July, 1864. He wrote much on the subject of the geology of the Cape Breton coal formations, and his elaborate work on the 'Coal Fields and Coal Trade of Cape Breton' (1871) is still a standard authority, has been reprinted, and the first edition sells for a large sum. In conjunction with Mr. Smith he contributed in 1829 a chapter on the geology of Nova Scotia (chiefly the eastern part) to Haliburton's 'Nova Scotia'. Many of his papers appeared in the earlier volumes of the Journal of the Geological Society

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* Moses Henry Perley should be referred to here. He was a native of New Brunswick and was born in 1804, and died in 1862. His writings mostly refer to his own province, but in 1851 he published at Fredericton, N. B., a "Catalogue of the Fishes of New Brunswick and Nova Scotia," which more directly connects him with natural history work here. (See Dict. Nat. Biog., vol. 45, p. 9.)

of London.   He also published at London in 1880, an inter-
esting volume of 142 pages, entitled "Notes on the Northern
Atlantic for the use of Travellers", which contains many
natural history observations.   He likewise is the author
of a well-known 'History of Cape Breton' (1869).   He was
a fellow of the Geological Society of London, as well as of
the Royal Geographical Society.

SIR JOHN WILLIAM DAWSON, geologist and palæonto-
logist, born at Pictou, 1820, and died at Montreal, 1899, has
become so famous in the world of science, that I will barely
mention him here; and he furthermore belongs to a later
period than would rightly place him among the pioneers.
It will merely be noted that the visit of Sir Charles Lyall
in 1842 filled him with enthusiasm and thereafter he began
a long series of geological and palæontological works, chief
of which, to us at least, was his 'Acadian Geology'.   In
1848 he prepared a little 'Hand Book of the Geography and
Natural History of Nova Scotia,' third edition in 1852,
which is of interest as being one of the first works to give
anything like a general scientific list of our fauna.   It had
been preceded in this respect, by the lists in the second
volume of Haliburton's "Nova Scotia," 1829, which were
supplied by various persons.

There are four others, who although but visitors to the
province, gave a most marked impetus to the study of local
geology and mineralogy.   In May, 1826, FRANCIS ALGER of
Boston visited Nova Scotia and in the next year published
his "Notes on the Mineralogy of Nova Scotia" (Silliman's
Journal of Science and Arts, vol. 12, June, 1827, p. 227); and
in 1828 and 1829 appeared CHARLES T. JACKSON and Francis
Alger's elaborate "Description of the Mineralogy and Geo-
logy of a part of Nova Scotia" (Silliman's Journal, vol. 14
[July, 1828], pp. 305-330, with geological map; vol. 15 [Jan.
1829], pp. 132-160, 201-217).   This coloured geological map
is the first we had.   Their work profoundly affected the in-

vestigation of our formations and was undoubtedly the incentive which induced Gesner and Webster to devote their leisure to such studies.

In 1841, SIR WILLIAM E. LOGAN made a tour of Nova Scotia, which he described in a paper, and two years later he measured the fine South Joggins section. In 1842, SIR C CHARLES LYALL came here, and one thing he did was to place our local observers in touch with other workers. He and Logan were the men who encouraged Dawson to take up his life's work..

THE HALIFAX MECHANICS' INSTITUTF.

In tracing what led up to the foundation of the Nova Scotian Institute of Natural Science, we must go back to the time when mechanics' institutes became popular and held their sway for a quarter of a century or more.

The first Mechanics' Institute, properly so called, was organized in Glasgow by George Birkbeck in 1823, being followed in 1824 by that at London. From them soon sprang many others, on a wider basis, the original idea having been merely to teach mechanics the principles of their trades. From these institutes have arisen various technical and other organizations.

The Halifax Mechanics' Institute was established on 27th December, 1831, at a meeting of the shareholders of the Halifax Mechanics' Library. It was affiliated with that organization, which had been established on 17th October of the same year, and all Institute members had to financially support the Library. The Institute's objects were the cultivation and diffusion of knowledge in the arts, sciences, and general literature, and the collection of models, drafts, specimens, books of reference and other materials tending to instruction and improvement*. The original officers were: Dr. William Grigor, president; John Leander Starr and

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* The annual meeting for the election of officers, etc., was held on the last Wednesday of December, until February, 1838, when the date was changed to the first Wednesday in May.

Joseph Howe, vice-presidents; William M. DeBlois, treasurer; John Sparrow Thompson, secretary; and Robert Lawson, procuror of models, etc. (curator). Dr. Grigor held office till 23rd December, 1833. The subsequent presidents were, Joseph Howe (Dec. 1833 to Dec. 1834), John Leander Starr (Dec. 1834 to Dec. 1835), George Rennie Young (Dec. 1835 to Dec. 1837 or May 1838), Andrew McKinlay (from Dec. 1837 or May 1838 to May 1849), Dr. Daniel McNeil Parker (May 1849 to May 1852), Rev. Dr. Alexander Forrester (May 1852 to May 1855), Andrew McKinlay (May 1855 until his death, 29th Sept. 1867), after which the presidency was vacant, but James Thomson continued as vice-president until about the autumn of 1868.*

Meetings for lectures were held once a week during the session, and a museum was immediately established and gradually grew. The museum was at first in the same room as the library, namely the lower part of the premises occupied by Mrs. Grover as a boarding house, in Hollis Street. Subsequently gatherings were held, and the collections accomodated, in two rooms in the west end of Dalhousie College on the Parade.

The Institute became very popular and a most interesting series of lectures was given, by prominent local men, on scientific subjects, the fine arts, literature, etc., and art exhibitions were held, all of which were well attended.†

Gradually, however, doubtless in the '50s, the interest in it began to wane, and about 1860 it had become more or less dormant and finally became defunct as far as active work was concerned, leaving its museum, with old Errol Boyd, the curator since 1847, as the only tangible remains of its former glory. From that time the old officers appear to have just continued nominally in office, their places not being filled up as death took one after another, until in 1868 there

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* The presidential dates I believe will be found accurate, but absolute verification has not been made in all cases by reference to newspaper files. The record books of the Mechanics' Institute are not known to be in existence.

† In 1845 a Mechanics' Institute building was erected in Dartmouth, N.S.

remained only a vice-president, a treasurer, a curator, and five committeemen. In that year the trustees handed over the collection to the Provincial Museum, which action finally closed the history of the society.

It may be mentioned that about 1839 a society known as the Halifax Literary and Scientific Association was in existence, with W. C. Silver as president, and it at least survived till the next year, but I know nothing further of its history. (See Belcher's Almanac for 1840).

The Nova Scotian Institute of Natural Science.

In 1859 the Nova Scotian Literary and Scientific Society was doing some active work, no doubt formed, about then, from the salvaged wreckage of the Mechanics' Institute, and with objects intended to save the new association from running on the rocks which had caused its predecessor to founder. It published its Transactions for the period from 4th January to 3rd December, 1859, (Halifax, 1859), probably not more. In the next year Dr. Charles Cogswell was its president, being followed by Robert Morrow; and in April 1862, I believe, J. R. Willis read before it a paper on our shells.

There seems to have been various interests working in this society, which possibly did not harmonize, and the scientific men proposed to form an organization that would be all their own.

In February, 1861, the second International Exhibition of London received its charter and was opened on 1st May of the following year. Nova Scotia had been rapidly coming into notice. Coal was being largely produced, iron was being mined, and gold had lately been discovered, and it was considered to be a favourable opportunity to bring our natural resources before the eyes of the world. Specimens for the purpose were collected with much enthusiasm and were forwarded to London. Those who had been engaged

in this work, felt the need of more scientific help and fuller information regarding our animal, vegetable and mineral resources. Thus was suggested the necessity of a permanent organization that might foster the scientific spirit among us. In other words, a few men of scientific tastes had individually devoted energy to studying our fauna, flora and geology, but it was felt that they should have a technical society of their own to publish the results of their observations. The Mechanics' Institute was dead in all but name, and had not been exactly on the lines now required. The recently formed Literary and Scientific Society formed a basis for a new structure. The scientific members were more energetic for the time being, and dropping the purely literary element, decided to form a society which would confine its activities to science alone.

General Hardy, the only survivor of those present at our inaugural meeting, writing on 20th January, 1913, says, "I remember well the friendliness and hearty co-operation of our efforts to set forward the development of local knowledge of the natural history and resources of the province· We were a band of enthusiastic lovers of nature: hunters and woodsmen, zoologists and geologists, botanists and fishermen, historians and antiquarians, each zealous of improvement in his own particular sphere of knowledge or science."*

Several preliminary meetings were held in the office of Robert G. Haliburton, Barrington Street, and a roster of prospective members was made out on 26th December, 1862, at one of these meetings held to talk over the matter. Finally on the 31st of that month (1862), at a general meeting held

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* W. Gossip says "The Institute originated with a few gentlemen who believed, that in a province which contained vast mineral resources, and further was an untrodden field in other branches of natural science, there would be found men of culture and experience who would gladly lend their aid to develop them into successful activity." (Trans., vi, p. 157; see also Lawson, Trans., ix., p. viii).

in the hall of the Medical Society at Halifax,* there was organized the NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE.

At this meeting John Matthew Jones was in the chair, and there were also present Thomas Belt, Samuel Gray, Dr. John Bernard Gilpin, William Gossip, Robert Grant Haliburton, Captain Westcote Whitechurch Lyttleton, Henry Poole, Captain Campbell Hardy, R. A., John Robert Willis, and Philip Carteret Hill.

What took place is told in the manuscript minutes:

"The chairman read a draft of the bye-laws that had been prepared by the council, and intimated the desire of the council and officers that there should be a fresh election, and the resignation of the present office-holders and members of council should be accepted.**

"Capt. Lyttleton and Mr. Haliburton reported that they had waited on His Excellency, the Lieutenant Governor, who had consented to act as patron of the society.

"It was moved by Mr. J. M. Jones, seconded by Dr. Gilpin, that P. C. Hill, Esq., be president for the ensuing year; which passed unanimously.

"Moved by T. Belt, seconded by Capt. Lyttleton, that J. M. Jones and R. G. Haliburton be vice presidents for the ensuing year; which passed unanimously.

"Resolved on motion of Capt. Lyttleton, seconded by J. M. Jones, that the following gentlemen compose the council for the next ensuing year: Dr. Gilpin, Rev. J. Ambrose, Henry Poole, Captain Hardy, T. Belt.

"Also resolved on the motion of Dr. Gilpin, seconded by J. M. Jones, that J. R. Willis and J. B. Young be secretaries of the Institute.

"Resolved on motion of J. M. Jones, seconded by Dr. Gilpin, that Capt. Lyttleton be treasurer for the ensuing year.

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*The Medical Society of Halifax originated in 1854.
**This doubtless refers to the officers and council of the N. S. Literary and Scientific Society.

"Resolved that the next monthly meeting be held on the 19th January and afterwards at the regular time on the first Monday of each month; also that the secretaries make enquiries as to procuring the Mechanics' Institute room at Dalhousie College for monthly meetings, or some other suitable place.

"Resolved that at the next meeting each member be entitled to bring a friend.

"The bye-laws, with some slight modifications, were unanimously adopted."

According to the bye-laws, monthly meetings were to be held for the reading and discussion of papers relating to natural science, and four field meetings were to take place annually. The Institute was to "undertake the publication of lists of the various natural productions of the province, with such observations as their respective authors may deem necessary. That, as far as the funds of the Institute will permit, the president's address, the list of native productions, and a selection of the papers read at the meetings by members be published as the 'Transactions of the Nova Scotian Institute of Natural Science' and distributed gratuitously to the members."

The admission fee was 20 shillings (afterwards $4.00) and the annual subscription 10 shillings (afterwards $2.00), The election of associate members was authorized in October, 1863, with an admission fee of 10 shillings and an annual subscription of 5 shillings.

Those whose names appear on the original roll as elected "26th December, 1862," and who must be taken as the original members, with three exceptions afterwards referred to, are as follows:—Rev. John Ambrose, M. A. (St. Margaret's Bay); J. Bernard Gilpin, M. D.; J. R. Willis, (name scratched out and marked "retired Dec. 1863"); Thomas Belt; Capt. C. Hardy, R. A.; Andw. Downs; R. G.

Haliburton; Capt. Westcote Lyttleton; J. Matthew Jones; Samuel Gray; Colonel [W. J.] Myers; Wm. Gossip; Lieut. [Francis] Duncan, R. A., (Canada); J. Young; Rev. Alex. Forrestor, D. D., (Truro, marked "erased for non-payt. adm. fee"); H. G. Flint (Yarmouth); W. Lyttleton; P. C. Hill; Dr. Gesner (New York); Prof. How, D. C. L. (Kings College, Windsor); Rev. D. Honeyman (Antigonish, name erased); Henry Poole; J. Hunter Duvar; and Rev. Dr. Cramp (Wolfville). All were of Halifax or its vicinity, except those otherwise mentioned. There are columns for "date of election" and "date of admission" (the latter not being filled in). I think the "date of admission" was the time when a man qualified by the actual payment of the admission fee. The dates given in the earlier printed lists seem to have been the latter ones, and therefore do not indicate the date of election, which has produced some confusion in our ideas of when a man joined the Institute. If these dates were accepted, we would be in the peculiar position of believing that the society had no members when it was organized. As the first council minute-book is missing, we find it impossible after 1864 to say exactly when a member was elected and sometimes have to take the time when the fee was paid. There can be no doubt whatever that of those mentioned in the preceding list, the following did not pay admission fees, and cannot therefore be considered as original members: Lt. Duncan, Rev. Dr. Forrester, and Rev. D. Honeyman, the latter coming up again for election and being admitted on 3rd December, 1867. We also find that Dr. Gesner was re-proposed on 2nd November, 1863.

At the first ordinary meeting, held at Dalhousie College, on 19th January, 1863, Dr. J. B. Gilpin had the honour of reading the first paper, viz., on "The Common Herring of Nova Scotia," followed by one by Captain (now Major-General) Hardy, R. A., on the "Nocturnal Life of Animals

in the Forest". General Hardy, I am greatly pleased to say, is still living, at 3 Victoria Park, Dover, and has reached the age of eighty-one years. He takes a deep interest in all our affairs and is our sole surviving original member.*

At the February meeting, at which the patron, the Earl of Mulgrave, was present, and spoke at some length, the president, P. C. Hill, D. C. L., read an address. Hill, who was then mayor of Halifax and a prominent gentlemen of the time, attended only this one meeting and was probably merely a figure-head, being succeeded in October, 1863, by J. Matthew Jones, since when the society has had, as its presiding officer, men who have been directly interested in scientific work.

In April, 1863, the place of meeting was changed to the "Institute Room" in the Province Building, the use of which was given by the government, where it assembled till May, 1871. From October 1871 till April 1887, it met in the Provincial Museum; then for a short while in the Provincial Engineer's office, Provincial Building; from December 1888 to April 1890 in the Art School; and thereafter mostly in the Legislative Council Chamber and Assembly Room, and

* Major General Campbell Hardy, late R.A., was born at Norwich, England, on 10th October, 1831, son of the Rev. Charles Hardy, M.A. He was educated at the Royal Military Academy, Woolwich. He entered the Royal Artillery as ensign on 19th December, 1849; became lieutenant on 11th August, 1851; and captain on 23rd February, 1856. He served in Nova Scotia from February, 1852, to August, 1867, five and a half years of which period he was Inspector of Warlike Stores and Firemaster. In 1866-7 he was also Inspecting Field Officer of the Nova Scotia Militia Artillery. While in Halifax he lived on Robie Street (Camp Hill). In 1869 he published in London his "Forest Life in Acadie", a work which is very highly valued for its accurate and delightfully written accounts of forest life and sporting adventures, he being a most ardent sportsman and lover of nature, as well as a skilful artist. He was commissioned major on 5th July, 1872; lieutenant-colonel, 16th Jan., 1875; colonel, 16th Jan., 1880; and was retired on full pay on 29th May, 1880, with the honorary rank of major-general, and now resides at Dover, England. Outside of his period of service in Nova Scotia, his life has been somewhat uneventful, but he has given much of his time to his favorite studies and sport. He looks back upon his Acadian forest experiences as the most delightful phase of his past. He published in our transactions six papers, viz., on Nocturnal Life of Animals in the Forest, The Capelin, Provincial Acclimatization, The Beaver in Nova Scotia, Nova Scotian Conifers, and a Nova Scotian Naturalist (Andrew Downs). To illustrate his paper on the beaver, he prepared a most carefully constructed model of a beaver house in 1866, which was shown at the Industrial Exhibition, Paris, 1867, and is now in the Provincial Museum.

finally on 13th December, 1909, it began to meet in the Technical College.

One of the pleasant features of the early years of the Institute were the field-days which were held in the summer. Although the bye-laws called for four annually, it was not found possible to have so many. The first was held on 11th June, 1864, at French Village, St. Margaret's Bay, to investigate some Indian shell-heaps, and on 21st of the following September one took place at Cole Harbour for the same purpose. In 1865 the members drove to the Waverley gold mines on 1st July; and on 26th June of the next year, a pilgrimage was made to the grave of Titus Smith in the woods near Dutch Village, where an interesting paper was read on that naturalist's life and work, and the president's museum at "Ashburn" was also inspected. From then till 1870 no excursions took place, although it was announced that one would be held on 28th June of the last-mentioned year in the vicinity of St. Margaret's Bay to explore shell-mounds there. On 21st June, 1871, a field-day took place at the Montagu gold mines, and another on 24th August, 1876, at Grand Lake. The last ones took place on 3rd and 24th August, 1878, at Point Pleasant and York Redoubt respectively. Since then they have been often proposed, but never carried out. They were enjoyed at the time, and gave members an opportunity of becoming acquainted with natural history in the field, under the guidance of competent leaders. They are now, at least, unpopular, perhaps because of the greater stress of present-day business life. Other societies are meeting with similar troubles in Nova Scotia; although in Ottawa and Montreal, field excursions are still kept up, as well as in England.

William Gossip, writing thirty-six years ago (October, 1876), says, "At the formation of the Institute it was supposed that these excursions would be generally taken advantage of, as pleasing and popular features of our proceedings.

In no one year, however, since that time, has there been found much enthusiasm in their behalf or willingness to engage in them. This may be attributed to the fact that each member of the Institute considers his public or private business of paramount interest, and the pursuit of science in this way quite a secondary object. I often think it a pity that it should be so at all times, and that we lose a large amount of knowledge and profitable recreation by not attending to these pleasant meetings."

The first part of the society's "Proceedings and Trans-actions", for the session of 1862-3, was published about November, 1863; and the first volume (for 4 years) was completed and its title-page issued in 1867. It contained articles on zoology by Gilpin, Jones, Ambrose, Willis, Belt, Downs, Duvar, and Sinclair; on anthropology by Halibur-ton and Gossip; on botany by Lawson and Hardy; on geology and mineralogy by Belt, How, Gossip, Honeyman, Jones, Hamilton, and Morton; on palæontology by Poole; on metallurgy by Gesner; and on meteorology, by Myers.

The earlier volumes were edited by its secretary and president, William Gossip, whose long experience in pub-lishing assured good proof-reading and typographical style. In this work he was succeeded by Dr. Honeyman from about 1887 till 1889, whose eye for such work was not so well trained; then by Dr. MacGregor till 1901; by Piers till October 1908; and then by Dr. Creighton and Dr. MacKay.

In looking over the earlier lists of members, a noticeable feature is the number of army men who joined and often assisted in the active work of the society and by contributing papers. Pre-eminent among these was our vice-president, Captain (now Major-General) Hardy of the gunners, the author of that delightful work, "Forest Life in Acadie'' (Lond., 1869), a book which now brings a large price. He was a charming writer, a keen sportsman, a good zoologist and woodsman, and a skilful artist.

Among other service-men were Capt. W. W. Lyttleton;
Col. W. J. Myers; Lieut. F. Duncan, R. A.; Capt. C. L'Es-
trange, R. A. (who served on the council); Lt. Col. M.
Clifford, R. A.; Capt. J. R. King, R. A., (on council); Major
D. L. Colthurst, 17th Regt., (on council); Capt. W. D.
Thompson, 17th Regt., (on council); Lieuts. H. C. Deane,
(member of council), and L. F. W. Dwyer, 17th Regt.; Lieut.
H. H. Webber, R. A.; Lt. Archibald Anderson, R. A.; Capt.
Tulloch; Lt. C. Morley, R. A.; Lt. H. J. Hope Edwards,
60th Regt.; Lieut. Hon. A. H. Fulke Greville, 60th Regt.;
and others, most of whom belonged to the artillery and
were probably brought in largely by Capt. Hardy. With
the exception of Surgeon Capt. Barbour, we have lately had
no recruits from this source, although invitation cards have
been sent to the army departments for a number of years.
As a matter of fact, the army man has changed in more
senses than one since the first years of the society, and
strange though it may seem, the abolition in 1871 of the
old purchase system seems to have had something to do with
it.

We have referred to the field-meetings of the Institute,
but there was another style of entertainment that was in-
dulged in on two occasions, and on each was successful and
well attended. On 6th July, 1865, a conversazione was held
in the hall of the Horticultural Gardens, at which about
two hundred persons were present. Popular scientific ad-
dresses were given and refreshments served. Another of
like character was held on 20th January, 1873, in the Provin-
cial Museum and appartments of the Post Office, with His
Excellency Sir Hastings Doyle in the chair, and about the
same attendance. It was the last that took place.

The Provincial Museum had been established about
October, 1868, through the strenuous exertions of some of
the prominent members of the Institute, and it became the
repository of all specimens that were donated to the society,

including many which illustrated papers read before it. Further reference will be made to this later on.

About 1867 a grant of $200.00 was first received by the Institute from the Provincial legislature, and $100.00 was granted in each of the two succeeding years at least. The Legislature for many years financially aided the, society, and in 1890 this grant was raised from $400.00 to $500.00 to meet the cost of printing a thousand copies of the Transactions.

It should be noted in passing, that in the winter of 1872-3 the sessions of a so-called School of Science were held in connection with the Provincial Museum, Dr. Honeyman lecturing on zoology; and that on 1st March, 1878, there was established at Halifax a Technological Institute, for instruction in technical subjects, of which Prof. Lawson was president, Dr. Somers, vice-president, and Dr. Honeyman, secretary and treasurer, with a competent corps of instructors, nearly all of whom were members of the Institute of Science. It had a class-room in the Stairs building, 74 Bedford Row, but some classes were held in the Museum and elsewhere. After three sessions, it passed out after May, 1880, for lack of funds. It was the unsuccessful forerunner of the present Technical College, and yet I never heard its name mentioned during all the agitation leading up to the foundation of the latter institution.

The visit to Halifax in May, 1873, of H. M. S. *Challenger* with Prof. Wyville Thomson on board, gave our members an opportunity of becoming acquainted with the most modern and improved methods of marine research, and stimulated such as were interested in that subject, as did also the sojourn here, from August to October, 1877, of the U. S. Fish Commission's ships with their corps of specialists.

The year 1874-5, unfortunately, is spoken of as our year of greatest intellectual dearth, judging by the small number of papers submitted, ·namely eight, (*vide* MacGregor's

address, 12th November, 1888). The average yearly number since 1862, has been between ten and eleven; and the average length of each paper, eleven pages. For the first twenty-five years, the average number of papers was about twelve, and the average length, nine pages.

On 2nd April, 1879, the Institute of Science was honoured by having its then and subsequent presidents made *ex-officio* Fellows of the Royal Microscopical Society, a distinction which our presiding officer still enjoys.

In the year just mentioned, the Institute deliberated on a collection of supposed rude, prehistoric pottery discovered in the water of Grand Lake. The few who had their doubts, were afterwards proved to be right when more careful investigation showed that they were merely disk-like concretions of iron and manganese oxides about a nucleus of quartzite! It is one of the very few little episodes of a semi-laughable kind we have to look back to.

On 5th and 15th October, 1884, a revised constitution and bye-laws were adopted. With the exception of the addition of a curator or librarian to the list of officers, the changes from the older bye-laws and unwritten laws were not material.

The session of 1888-9 was an epoch-making one in the annals of the society. Dr. James Gordon MacGregor was elected president on 10th October, 1888, and held office till November, 1891. It was a period of regeneration. A month after taking the chair, he gave a masterly address on the Institute's affairs—the first of the regular series of annual presidential addresses which we have since had, the older contributions of the kind having been at rare intervals. He carefully analysed the society's history, found that the period of greatest activity was the first few years of its existence, and that since 1867 it had kept oscillating with an average of about eleven papers a year. The lowest ebb, as has been remarked, was in 1875. About 304 papers had been pub-

lished down to 1888, a period of twenty-six years, mostly on the natural history and geology of Nova Scotia, and averaging about nine pages each.

It was felt that the society's activity had reached a critical point. Progress was not being made, activity was decreasing; some of the most energetic members had died and few young men were ready to take their places. He admitted that in the early history of a country it is comparatively easy to make additions to the knowledge of its natural history and geology. He thought, however, that scientific education in the province had not kept pace with scientific investigation.

He attacked the whole problem with all the energy and extreme keeness of intellect for which he was noted, and placed the Institute on a higher plane than it had been. Perhaps we may have to wait for another MacGregor to tackle the problems that now face us!

One result of MacGregor's exertions was the phenomenal growth of the library, which will soon receive notice. In 1890 he increased the edition of the Transactions to 1000 copies, which were sent in exchange to learned institutions and libraries over the whole world, thus making our volume a more acceptable means of gaining a hearing for our most-known workers who had begun to think that publication of their papers in more-widely circulated journals, which welcomed them, was an advantage. This enlarged edition was of great benefit to us in another way, as it was the means of rapidly building up our library by the much larger number of exchanges which were thereby received.

Another result of MacGregor's ideas of the needs of the case, was that on 24th March, 1890, at a general meeting, the name of the society was changed to the NOVA SCOTIAN INSTITUTE OF SCIENCE, an action which was opposed by ex-president Somers and a few of the old members*. The

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*The Society was incorporated by act of the N. S. Legislature in the same year, 1890.

dropping of a single word is but a little matter in itself, but it widened the scope of the society to a large extent. It was felt that while "natural science" was retained in the name, others would consider it ·to be merely a natural history association, and it was found difficult to get general scientific organizations to exchange with it. It was also thought that no limitations should be be placed on what the society should consider its field. As a result of this change, we have since had a number of papers on physical and chemical subjects, etc. I am aware that one of the most learned biologists of the United States regrets very much that we have departed from our old tradition of admitting only papers which have a manifest local bearing, leaving such purely technical papers as have been mentioned for the special journals which are devoted to such subjects.

Down to the time now under consideration, the Institute had had the field of science in Nova Scotia all to itself, for the Gold Miners' Association of about 1884 published little or nothing. On 30th March, 1892, however, the Mining Society of Nova Scotia was organized, absorbed the Gold Miners' Association, and began to publish its yearly "Journal." Although all of the papers which appear in the latter might not, possibly, be suitable for the Institute, yet there is no doubt it has deflected to itself a number of contributions which we would be glad to have had.

In December, 1906, the engineers formed an organization of their own, known as the Nova Scotia Society of Engineers; but publication so far does not seem to have been adequately taken up by them. It is to be hoped, perhaps, that some sort of affiliation may be possible among these various societies.

The foundation of the Royal Society of Canada in 1882 has also had a marked effect on the production of our Institute, as many papers on Nova Scotian subjects have appeared in the more notable society's publications, which otherwise would have been given to our own.

All of these influences have undoubtedly worked to the detriment of the Nova Scotian Institute.

A condition of affairs arose in 1901 which it was thought might bring good results. Members of the Institute in the university town of Wolfville, under the enthusiastic leadership of Prof. Haycock and other members of the college staff, expressed a desire to form a sub-organization. It was thought to be a good time to form affiliated branches throughout the province which would be of mutual benefit to all concerned.

Accordingly on 28th May, 1901, the KING'S COUNTY BRANCH OF THE INSTITUTE was organized at Wolfville, with Prof. Haycock as president. Associate members were permitted to join the branch for a nominal fee of twenty-five cents a year. It was very successful at first, held four annual sessions and read or discussed papers of interest, but ceased to exist after the session of 1903-4.

The summer of 1901 saw the departure of Dr. MacGregor for Edinburgh University to take the chair of natural philosophy there, and the Institute joined with others in a farewell dinner to the man who had done more than yeoman service for our society. While appreciating and delighting in the well-deserved honour that had thus come to one of the province's most talented sons and one of our fellow members, the whole society could not but deeply feel his loss. Possibly I may be pardoned for expressing my own humble opinion that his is the keenest intellect that Nova Scotia has produced.*

I shall not proceed further with a general narrative, as the past decade is clear in all of our minds, but will give a few particulars of the growth of the library and of the museum, and then concise sketches of the presidents and other men foremost in the society's affairs. In respect to the biographical notes, Sidney Lee, editor of the " Dictionary of National

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*The sudden death of Prof. J. G. MacGregor. D. Sc . LL D.; F. R. S.; F.R.S.E., F.R.S.C., at the age of sixty-one, took place at Edinburgh in May, 1913, a few months after the preparation of this paper.

Biography," says (and he should know) that no biography can or should be written until the culminating point, death, has closed the record. There are also other self-evident reasons why I will confine myself, in the biographical section, to merely remarks on those worthy labourers who have passed to rest.

THE LIBRARY OF THE INSTITUTE.

Although the acquisition of a library was no doubt in the minds of the original members in 1862, yet the earliest mention of a collection of books being formed is in March, 1864, when was announced the receipt of the first book donations to the institution, viz., the Second Report of the Scientific Survey of the State of Maine, and the Report of the Natural History Society of Newcastle-upon-Tyne. Such was the modest beginning of a library which now contains nearly 36,000 books and pamphlets. For some twenty-five years, society journals were very slowly added by exchange. It was not until the revision of the bye-laws in 1884, that a librarian was considered at all necessary, to which office A. J. Denton was elected on 21st October, 1885, which position he held for four years. When I first remember the library about 1887, it was contained in about three small book-cases in the hall outside the Provincial Museum, which was then situated on the top floor of the Post Office. I know, however, that even the few scientific journals it then had, gave me as a lad the keenest pleasure in perusing them. In 1888 the books were put in order and binding to a larger extent was begun.

Feeling that the possession of a good library of society periodicals was one of the principal requirements of a scientific institution for research, if its members hoped to keep abreast with progress elsewhere, Dr. MacGregor, during his energetic presidency, with the assistance of Mr. Bowman, the librarian, devoted much attention in 1889 and 1890 to

increasing the exchange-list, and with this end in view the edition of our "Transactions" was in 1890 increased to one thousand copies, and the question of dealing adequately with the binding of exchanges was actively taken up. (See MacGregor's Address, 8th October, 1890.). In November, 1889, the Institute exchanged with only about one hundred institutions, but steps were being taken to increase this number to three or four hundred, and this was ultimately brought up to seven or eight hundred.

The library then began to grow by leaps and bounds. Very soon it could not be accommodated in the Post Office hall, and in 1894 the foreign section of it was removed to Dalhousie College and eventually all of it, where Mac-Gregor had it constantly under his eye, sharing with Mr. Bowman the great labour connected with its management, labour which was given willingly and gratuitously by these otherwise busy gentlemen.

Still it grew till it soon was beyond the capabilities of a small society with limited means, to look after it properly. Seeing that such publications, from every quarter of the world, and containing the very latest results in science, were of use to the whole province and not only to a limited few, the Institute by letter to the Provincial Secretary, dated 21st December, 1899, stated its willingness to intrust its library to the custody of the government (the right of property remaining with the society) on condition that it "should be made the nucleus of a public library to be maintained by the government in connection with the Provincial Museum, and to be open to all who may wish to use it, under such restrictions only as might be necessary for the safe-keeping of the books," and also on condition that the government appoint "a competent librarian to take the library in charge."

The government saw the wisdom of acquiring these books under the conditions laid down, and the result was the foundation of the PROVINCIAL SCIENCE LIBRARY OF NOVA

Scotia in the summer of 1900, under control of the Depart-
ment of Public Works and Mines. The scientific works of
the Legislative Library were passed to it in July and the
transfer of the Institute's books from Dalhousie College was
begun on 17th November, while manuals, textbooks, etc.,
were added by the government by purchase, and the whole
was thrown open, free, to the public of the Province, soon
after, thus becoming the first public library for the whole
of Nova Scotia. The Mining Society also deposited its books
there till February, 1907, when it fitted up a room of its own.
A government grant of $500 a year for the support of the
Science Library was given up to 1904; but after that, was
withdrawn, and I regret to say that it is now without direct
financial support.

Having utterly outgrown its quarters in the so-called
Burns and Murray building on Hollis Street, the library was
removed in May-June, 1910, to a new and larger stack-room
in the Technical College.

On 31st December, 1911, it contained 45,497 books and
pamphlets, of which 34,085 (about 75 per cent.) belong to the
Institute. The average yearly increase to the society's library
is 1,841; and to the Science Library proper, 1,099; a total
average yearly increase of 2,940.

THE PROVINCIAL MUSEUM.

Dr. A. H. MacKay has aptly spoken of the Provincial
Museum as "the ward of the government, but the child of
the Institute." The society has always taken a very vital
interest in it, for it was formed at the solicitation of its mem-
bers, and it has always deposited in it such specimens as were
donated to it, so that in one way it is the Institute's museum
in part, although under control of the government.

The origin of the collections it contains goes back to 1831
when the old Mechanics' Institute began to form a general

museum, which grew until 1860 when it came to a standstill owing to the dormant state into which that society had passed. Its curators were: (1) Robert Lawson, 1831; (2) John Fairbanks, about 1833; (3) John McDonald, 1835-46; (4) Andrew Downs, 1846-47; and its last and best remembered curator, Errol Boyd, (elected in May, 1847), a man, however, not well fitted for the position by education or native talent· The museum remained in Dalhousie College, but was going to pieces from lack of care.

The establishment of a provincial museum was first proposed in 1862, when collections were being made for the London International Exhibition. The Rev. J. Ambrose and J. M. Jones had (about 1861) suggested to J. R. Willis the propriety of taking some steps in the matter, and the first-named gentleman had written a communication upon the subject, to "tune" the newspapers, as he termed it. (Trans., vii, 409, foot-note). Nothing resulted immediately from this agitation. In 1865 Rev. D. Honeyman and J. R. Willis presented a memorial to the government strongly advocating the establishment of such an institution, and Willis appeared before a committee which was to report upon the matter. At the time of the preparation for an exhibit at the Paris International Exhibition which opened in April 1867, Honeyman being secretary of the Nova Scotia Commission, the project was vigorously pushed, with a successful issue. In the beginning of 1866 Dr. Honeyman had proposed to A. MacKinlay, trustee of the Mechanics' Institute, to take the museum of that defunct institution, whose collections were becoming ruinous, and to make it the beginning of a provincial museum. MacKinlay and the other trustee, James Forman, agreed to the proposal. Honeyman then applied to the Provincial Government for accommodation for a museum in the new building (now the post office) which was then in course of erection, and the government agreed to set side a room there for the purpose. The foundation of

a museum being now assured, the Nova Scotia Commission purchased natural history collections with the understanding that they were to be brought back from Paris and deposited in the proposed museum. How, writing in January, 1867, says that a space, 70 by 30 feet, had been set apart for a provincial museum in the province building (post office) then being built.

The Provincial Museum was finally founded in October, 1868, when Honeyman was authorized by the government to take possession of the room, where the Halifax Mechanics' Institute museum (thirty-seven years after its formation) was formally transferred by its sole surviving trustee, James Forman, to the Nova Scotian government and placed in the large room prepared for it in the post-office building. These specimens were incorporated with those which had been at the Paris Exhibition and which had been returned after its close on 3rd November, 1867. The latter included How's minerals and herbarium, Downs's birds, and Barnes's carboniferous fossils. The late Dr. Honeyman was appointed curator and remained so until his death on 17th October, 1889, and the extent of the then collection was largely the result of his zeal. It should be mentioned that to the Hon. William Garvie was due much credit for lending his support to the institution on its formation.

For thirty-one years the museum was of a general character, and after Honeyman's death remained *in statu quo*, but in 1899 the government at the strong solicitation of the Institute of Science, decided to give it more attention and wisely determined to cut it down to a representation of Nova Scotian products only, placing the foreign specimens in storage. In October, 1899, arrangements were begun to remove the collections to the Burns and Murray building, where they soon outgrew their quarters, and in October, 1910, they were finally removed to the Technical College.

When the museum was revised in 1899 there were retained 10,099 of the old specimens. From then till December, 1911, there were added 14,814 specimens, making a total of 24,913, or about 25,000 at the present time. Since 1900 it has received an average of 1,235 specimens each year. Allowing for specimens that had been discarded in 1899 because of lack of data, there can be little doubt that for the twelve years since then, the number of accessions exceeds the total number obtained from 1831 to 1899, a period of sixty-eight years.

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In closing these ragged and brief annals of our society, we find that, like those of Miss Mitford's Village, they are somewhat uneventful. I only regret that we have not had a Mitford to lend to our simple story the charm with which her genius invested the daily happenings of her little community.

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BIOGRAPHICAL SKETCHES.

One of my chief aims in bringing together these notes, has been, not only to give a few particulars and dates, but especially to present a little about the men, now gone from among us, who laboured for the Institute, for science, and for the country generally, to the very best of their abilities, humble or otherwise, without pay and I fear with but scant recognition of the value of their work. I distinctly feel that at such a time as this, instead of singing too much the praises of the society itself, of which we are more or less a part, we should give a few retrospective glances at the men whose shares first cut the virgin sod, and through whose success we cannot selfishly add one cubit to our height.

With this end in view I have prepared short biographical notes on our deceased presidents and other prominent members, which are appended hereto.

Deceased Presidents.

Hon. Philip Carteret Hill, K. C., D. C. L.—Born at Halifax, 13th August, 1821, son of Capt. Nicholas Thomas Hill, late Royal Staff Corps; died at Tunbridge Wells, England, 14th September, 1894. He was educated at King's College, Windsor, entered the legal profession, and received the degree of D. C. L. from King's College in 1858. Was mayor of Halifax for three years, October 1861 to October 1864; became provincial secretary of Nova Scotia in 1867 and again in 1874; and was premier in 1875, retiring in 1878. He was one of the original members of the Nova Scotian Institute of Natural Science, and its first president, holding office from 31st December, 1862 to 26th October, 1863. He attended only one meeting, and his connection with the society was in all respects slight, his position as mayor at the time doubtless making him a desirable nominal head at the inception of the institute. He was a man of education and literary, but not scientific, tastes, and possessed cultivated manners and financial means.

John Matthew Jones, F. L. S., F. R. S. C., zoologist.— Born at Frontfaith Hall, Montgomery, Wales, 7th October, 1828, son of Admiral Sir Charles T. Jones; died at Halifax, 7th October, 1888. He was educated at the Middle Temple, London, for a barrister, but being possessed of independent means, did not practice. About 1854 he went to New York and soon after came to Halifax, where he decided to reside, his relative, the Earl of Mulgrave, being then governor of the province. He spent sometime in Bermuda where his researches into natural history resulted in the publication, at London, 1859, of "The Naturalist in Bermuda".* At Halifax he resided from October, 1860, for a number of years, at "Ashbourne," Dutch Village, (which he purchased from his father-in-law, Col. W. J. Myers), and there he had a large

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*Günter named *Sygnathus jonesi* and *Gerres jonesi* (= *Eucinostomus pseudogula*) in his honour; and Goode similarly named *Belone jonesi* (= *Tylosurus acus*). These are Bermudian fishes.

private museum which, in 1866, contained seven or eight thousand specimens. He was an enthusiastic collector and gave generously to various museums. The Nova Scotian fisheries exhibit of the International Exhibition at London, 1862, was brought together under his management. He was an original member of the Institute of Natural Science and one of those who took the most active part in its establishment in December, 1862; he presided at the inaugural meeting, and the society owes a vast debt of gratitude to him for his enthusiastic labours in its behalf. He was its first vice-president, and its second president, serving in the latter capacity for ten years, 26th October, 1863, to 8th October, 1873, the longest presidential term we have had. His studies related chiefly to zoology, more particularly fishes, reptiles, and mollusca, of all of which he left lists, as well as birds, lepidoptera, and marine invertebrates, and the name by which he was jocosely referred to, "Bug Jones," was well known to the last generation. A pretty conceit on his gravestone represents a butterfly above a caterpillar crawling on a twig. His publications number about twenty-three items, 15 of which appeared in our Transactions; and next to Dr. J. B. Gilpin (24 items) he was the most prolific writer the Institute has had on zoological subjects. He was a Fellow of the Linnean Society of London (1st December, 1859 till about 1878), and an original Fellow of the Royal Society of Canada, as well as a member of the Entomological Society of Canada, and corresponding-member of the Natural History Society of New Brunswick, of the New Orleans Academy of Science, and of the Frankfurt Senckenbergische Naturforschende Gesellschaft. (See sketch of life, by H. Piers, Trans., x, p. lxxx, with portrait; List of Fellows of Linnean Society.)

JOHN BERNARD GILPIN, M. A., M. D., M. R. S. C., F. R. S. C., zoologist and ethnologist.—Born at Newport, Rhode Island, 4th September, 1810, son of J. B. Gilpin,

formerly of Vicar's Hill, Hants, England, who afterwards retired to Annapolis, N. S.; died at Annapolis, 12th March, 1892. He graduated from Trinity College, Providence, R. I., and took a course of medicine in England, afterwards practising at Annapolis, and spending his leisure in the study of the animal life of the western part of the province. In 1846 he moved to Halifax where he resided for forty years, and then returned to Annapolis where after a period passed in retirement from all mental activities he passed away in 1892. He was an original member of the Institute of Natural Science, and with his friend Jones was one of those who took the most active part in its organization, and his paper on the herring was the first read before it and published in its Transactions. He served as vice-president, and succeeded as the third president on 8th October, 1873, holding office for five years, till 9th October, 1878. He was the society's most prolific writer of the period, his papers, which were long, numbering 24; but some of them being in several parts, 34 would convey a more correct idea of the number of his writings. Dr. Honeyman was the only one who surpassed him in the number of his contributions. Gilpin was a zoologist primarily,* and his papers deal with the mammals, food fishes, wild fowl, the eagles, and our Indians and their remains, and his article on Sable Island is still much referred to. His monographs on our mammals, with full descriptions of their habits, are still, although somewhat out of date, the chief source of information on the subject. Altogether he was probably the best student of the higher animals we have had. He possessed a racey, picturesque and attractive literary style, coupled with close accuracy in his statements and determinations. Furthermore he was a good draughtsman, wielding a ready pencil and brush, which assisted in illustrating his lectures. In

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*William Gossip says he was well known in British America and the United States as the Nova Scotian Zoologist (Trans. vi,, p. 158).

1882 he was nominated a foundation Fellow of the Royal Society of Canada. (See obituary notice, Trans., viii, p. xlvii; portrait in x, pt. 2.)

WILLIAM GOSSIP.—Born at Plymouth, England, in 1809; died at Halifax, 5th April, 1889. He came to Halifax at the age of thirteen, and in 1831 went to Pictou where he published the "Pictou Observer" newspaper. He returned to Halifax in 1834, and established a bookselling and publishing business which was continued till his death. For some years he edited and published "The Times" newspaper of Halifax. He was one of the original members of the Institute and on 26th October, 1863, was elected secretary, holding office till 11th October, 1871, when he was succeeded by Honeyman. The minutes during his secretaryship are very full and interesting and contain items of scientific value which never went into the printed Transactions. From 1871 to 1874 he was a member of the council; from 1874 to 1878, vice-president; from 9th October, 1878 to 13th October, 1880, the fourth president; and from then till 1889 again a member of the council or vice-president. From the establishment of the society, therefore, he took a deep interest in its affairs, and his services were specially acceptable as editor of the Transactions, a duty which he assumed from the first, his knowledge of printing and publishing being valuable for this purpose. He contributed five papers to the Transactions (four anthropological and one geological), besides some addresses and miscellaneous notes. Not being a scientific man by profession, he felt a diffidence in writing on such subjects. The Institute, however, owes him much for long and faithful service. (See obituary by Prof. Mac-Gregor, Trans., vii, 319.)

JOHN SOMERS, M. D., botanist.—Born in St. John's, Nfld., in 1840; died at Halifax, 13 March, 1898. He came to Halifax in infancy and was educated at St. Mary's College. In 1866 he graduated from Bellevue Medical College, New

York, and spent a year in active service as an assistant army surgeon during the American Civil War, after which he returned to Halifax where he practised till his death. He took an active part in the establishment of the Halifax Medical College in which he was professor of physiology. On the organization of the Technological Institute, Halifax, on 1st March, 1878, he became its vice-president; and in 1883 he was president of the Medical Society of Nova Scotia; besides which he was chairman of the Commission of Public Charities, a school commissioner, and occupied some other positions during his very active life. In January, 1875, he became a member of this Institute, and served for two periods as president, 13th October, 1880, to 10th October, 1883, and 21st October 1885, to 10th October, 1888—the first non–foundation member to be elected to that office. He contributed many papers on his favourite study, botany, including articles on the mosses and fungi, in the latter of which, I think, he was our first investigator. Of his eighteen published papers, 14 relate to botany, 3 to zoology, and 1 to microscopy. His determinations were, perhaps, sometimes too hastily made. He formed a large herbarium, which was, unfortunately, destroyed after his death, which makes a revision of his identifications impossible. (See obituary by Prof. Lawson, Trans., x, p. iii., with portrait; Dr. D. A. Campbell, Mar. Med. News, June, 1910, p. 186.)

ROBERT MORROW, comparative anatomist and zoologist.— Born at Halifax, 26th July, 1827, son of John and Mary Anne (Duffus) Morrow; died at Halifax, 5th August, 1885. His father came of mining stock from Co. Durham, England, and about 1835 was appointed United States Consul at Halifax, N. S., and later secretary of the N .S. railway. He was fond of studying, in an amateurish way, geology and conchology; and possessed collections of specimens relating thereto. In early life Robert entered the employ of the General Mining Association at the Albion coal mine,

Stellarton, where on the retirement of the manager he was
offered that position, but declined it.   He then came to
Halifax and in 1853 entered the firm of Wm. Stairs, Son and
Morrow, which connection he retained till his death, becom-
ing a son-in-law of Wm. Stairs the founder of the firm.   He
became a man of considerable wealth, was philanthropic,
built "Bircham," North West Arm, about 1869, and died
there after an illness of several years.   Much of his life
was given to the study of natural history.   He had been,
about 1861, a president of the old Nova Scotian Literary and
Scientific Society, but for some reason did not join the Insti-
tute of Natural Science until February, 1872, but then took
an active part in all its affairs, was a member of its council
from October 1873 to October 1880, and first vice-president
from the latter date till 10th October, 1883, when he was
elected president, which office he occupied up to his death.
In the basement of his residence he had a small aquarium for
studying the habits of fish, speciments of which he regularly
received from fishermen.   He also had a laboratory or work-
room, and to the consternation of his household, he not
infrequently kept fish until they were very unpleasant, in order
to separate the skeleton, which he and J. M. Jones would study
together.   He received a prize for his carefully prepared
skeleton of an Angler (*Lophius piscatorius*) and of a cod head,
which with his collection of West Indian shells are now in the
Provincial Museum.   His papers on the osteology of *Salmo
salar* and *Lophius piscatorius* were masterly productions.
He published nine papers in our Transactions, all but one
being on the anatomy of vertebrates; but also was interested
in general zoology and Indians, and made a special study
of Icelandic literature and Norse history..   He read two
papers relating to Greenland and Vinland before the N. S.
Literary and Scientific Society of Halifax in 1865, which
secured his election as a member of the Royal Society of
Northern Antiquaries (Copenhagen), and one, "Transla-
tion from the French relating to the Religious Beliefs of
the Indians prior to the Discovery by Cabot," before the

N. S. Historical Society in June, 1879. He was a corresponding member of the Society of Americanists. (See Morning Chronicle, Halifax, 6th August, 1885; Regan, Sketches and Traditions of North West Arm, 1908, p. 31; Stairs-Morrow Family History, Halifax, 1906.)*

PROF. GEORGE LAWSON, Ph. D., LL. D., F. I. C., F. R. S. C., botanist and chemist.—Born at Newport, Fifeshire, Scotland, 12th October, 1827; died at Halifax, 10th November 1895. Educated at Edinburgh University, and for a time was demonstrator of botany under Prof. J. H. Balfour and curator of the university herbarium, and prepared a catalogue of the Royal Society of Edinburgh's library. In 1858 he was appointed professor of chemistry and natural history in Queen's University, Kingston, Ont., and thereupon came to Canada. In 1863 left Queen's and took the professorship of chemistry and mineralogy in Dalhousie College, Halifax, a position which he held till his death. He added lectures on botany to those on his other subjects. He had made a study of agriculture before coming to Canada, and was secretary of the Board of Agriculture of N. S. from 1864 to 1885 when the government assumed the functions of the board, and was then appointed secretary for agriculture, remaining such till his decease. He conducted a Journal of Agriculture for twelve years, and published official crop and other reports. Some of the local exhibitions were under his management. He joined this Institute on 7th March, 1864, and in October became a member of council, served as second or first vice-president in 1869-73, 1878-82, and 1891-93, and filled the presidental chair from November, 1893, till his death on 10th November, 1895, being the second president to die in office.

His favorite study was botany, and he was one of the most accomplished students of that subject we have ever had in the province. Of his contributions to scientific societies, etc., from

*Since this paper was prepared, death has suddenly removed one of our most distinguished and most energetic past-presidents, Prof. J. G. MacGregor of Edinburgh University, who at this period was the eighth president, serving as such from Oct., 1888, to Nov. 1891. To no other man's endeavours does the society owe more.

the year 1846 when his first paper appeared, 93 were in botany, 5 in chemistry, 4 in zoology, and 5 were miscellaneous. Besides this he wrote many official reports, a few treatises, etc. To the Transactions of the Institute he contributed some 24 articles, mostly on botanical subjects, some of which were not published. A full bibliography of his writings to the end of 1894, will be found in the Trans. Royal Soc. of Canada, vol. xii. From the University of Giessen he received the degree of Ph. D., and LL. D. from McGill. He was a Fellow of the Botanical Society and of the Royal Physical Society of Edinburgh, and of the Institute of Chemistry of G. B., and original Fellow and president (1887-8) of the Royal Society of Canada, honorary member of the Edinburgh Geological and of the Scottish Arborcultural Societies, a corresponding member of the Royal Horticultural Society (Lond.) and of the Society of Natural Sciences of Cherbourg. (See obituary by Prof. MacGregor, Trans., ix., p. xxiv., with portrait; and by Dr. MacKay in App. B, Proc. Royal Society of Canada, 1896.)

EDWIN GILPIN, Jr., M. A., LL. D., D. Sc., F. G. S., F. R. S. C., I. S. O., economic geologist.—Born at Halifax, 28th October, 1850, son of Very Rev. Dean Gilpin and nephew of Dr. J. B. Gilpin; died at Gilpinville, North West Arm, Halifax, 10th July, 1907. Educated at Halifax Grammar School and King's College, Windsor, graduating in 1871; after which he took a special course in mining, geology and chemistry (M. A., 1874). Won the Welsford (1868), General Williams (1869), and Alumni prizes. After leaving college he practised as a mining engineer, being connected with the Albion colliery of the General Mining Association, in Pictou county. On 21st April, 1879, he became inspector of mines for Nova Scotia, in 1881 a member and secretary of the board of examiners of colliery officials, and in October, 1886, deputy commissioner of public works and mines, holding these various appointments up to his death. Was also lecturer on coal mining in Dalhousie College. On 9th November, 1903, he was granted the imperial service order for long and valuable

service, the investment taking place on 23rd March, 1904. He was an extensive writer on his favorite subjects of economic geology and mineralogy; and besides his official reports, published a work on the "Mines and Mineral Lands of Nova Scotia" (1883), and various pamphlets on the minerals of the province, while the Transactions of the North of England Institute of Mining Engineers and of the Royal Society of Canada, and various other societies, contain articles from his pen, all of which did much to make known the mineral resources of his native land. (See bibliography to 1894, in Trans Roy. Soc. Can., xii.). In April, 1873, he joined this Institute, having read before it in the previous month the first paper he ever prepared, and in 1881 became a member of its council and remained in it, either with or without office, till his death. He served as president for two years, 18th November, 1895, to 8th November, 1897. He published in our Transactions 30 papers and addresses, almost entirely on geology and mineralogy. He received the degree of D. Sc. from his Alma Mater, and LL. D. from Dalhousie (1892). He was a fellow of the Geological Society of London (1874), an original fellow of the Royal Society of Canada (1882), member of the American Institute of Mining Engineers and of the Canadian Society of Civil Engineers. (See obituary by Doane, Trans., xii, pt. 2, p. xxxi.; also Journal Mining Soc. of N. S., xiv., p. 103, with portrait.)

OTHER PROMINENT DECEASED MEMBERS.*

REV. JOHN AMBROSE, M. A., D. C. L., zoologist.—Born at St. John, N. B., 25th September 1823; son of Richard and Katherine (Phillips) Ambrose; died at Sackville, N. S., 12th September, 1898. He was born one month after the arrival of his parents from Cove of Cork (Queenstown), Ireland. Although originally from England, his ancestors had resided in Ireland for generations. Was educated at Truro and at

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*These sketches are arranged chronologically according to the years in which their subjects became connected with the Institute.

King's College, Windsor, (B. A., 1852; M. A., 1856; D. C. L., 1888). For over forty-four years laboured successfully as a clergyman of the Church of England at St. Margaret's Bay, Digby, etc., and was editor of ' Church Work' and 'The Halifax Church Chronicle'; and also was a governor of King's College. Married, 30th June 1853, at Liverpool, N. S., Charlotte Ann Barss (U. E. Loyalist descent). During a busy life as a country parson, he found in natural history a recreation, although not claiming to be an authority on the subject. He was an original member of the Institute and was proposed as a member of the first council, but as he lived at a distance from Halifax he could take but little active part in its work; and in 1890 was elected a corresponding member. He published six papers in its Transactions, all relating to either the fishes or birds of St. Margaret's Bay, where he was stationed for thirteen years and so had ample opportunity of gathering from the fishermen much information regarding the inhabitants of the deep. (See obituary, Trans. N. S. I. S., x., p. iv.)

ROBERT GRANT HALIBURTON, M. A., D. C. L., Q. C., F. R. G. S., ethnologist.—Born at Windsor, N. S., 3 June, 1831, son of Judge T. C. Haliburton ('Sam Slick'); died at London (?), March, 1901. Was educated at King's College, Windsor (matriculted 1845; B. A., 1849; M. A., 1852; D. C. L., 1877), and then studied law, becoming a barrister in July 1853, and practised in Halifax. Was secretary of the N. S. Commission for the London exhibition of 1862. From 1871 to 1876 he was in England in connection with some Nova Scotian coal areas in which he was interested; and in 1877 moved to Ottawa. Ill health compelled him in 1881 to give up his practice in Canada, and to spend the winters in tropical or sub-tropical climates, his movements during these times being often not known to his friends for long periods. Since then he devoted his attention chiefly to ethnological investigations, the study of the pigmy races being particularly attractive to him. He

was an original member of the Institute and active in its organization, the preliminary meetings having been held in his office⋅ served as its second vice-president (1862-3), but severed his connection with the society about 1880. He contributed to its early Transactions four papers on ethnological subjects and on the geology and economics of coal. His elaborate paper on 'The Fesitval of the Dead' attracted rather wide attention at the time of its publication. His writings elsewhere were extremely numerous, and a list of them will be found in Morgan's 'Canadian Men and Women of the Time,' 1898, p. 423. He was a fellow of the Royal Geographical Society and of the Royal Society of Northern Antiquaries (Copenhagen), a member of the American Association for the Advancement of Science, etc., and about 1875 was the first colonist by birth to be elected to the council of the Royal Colonial Institute.

COLONEL WILLIAM JAMES MYERS, F. R. Met. Soc., meteorologist.—Born, doubtless in Scotland, about 1807; died at Halifax, 15 April, 1867. Myers had been major of the 71st Regiment of Highland Light Infantry which had served in Canada, Bermuda and the West Indies from 1824 to 1846. He received his captaincy on 29th December, 1835; his majority on 22nd November, 1842; and on 19th March, 1847, retired on the half-pay of the Royal Staff Corps, being subsequently commissioned lieut.-colonel on 20th June, 1854, and colonel on 26th October, 1858, (vide Army Lists). He came to Nova Scotia from Quebec and settled in Windsor, where he lived for a while, marrying Jean Gordon, daughter of Rev. Archibald Gray of St. Matthew's Church, Halifax. Their daughter became the wife of our late president, J. Matthew Jones. Col. Myers left Windsor and came to Halifax about 1856, living at 'Ashbourne,' Dutch Village, afterwards well-known as the residence of his son-in-law, Mr. Jones. The past generation had pleasant recollections of him as a fine gentleman. He died suddenly while preparing to leave his house to attend

church, and is buried at St. John's cemetery. The very sad death of his son in January, 1870, will be recalled by many. Col. Myers was one of the original members of the Institute, and afterwards served on its council. He was a most enthusiastic student of meteorology, kept a very careful record of the weather at Halifax, as Henry Poole was doing elsewhere in the province, and I think his papers in our Transactions are the earliest full and systematic ones published here, although Poole, and possibly Hensley of Windsor, were in the field before him. This led to his election as a fellow of the Royal Meteorological Society. He published in our journal, notes on the weather at Halifax for four years, from 1863 to 1866. His work was then taken up by Frederick Allison in 1867, and the Dominion meteorological service was ultimately established in 1871.

THOMAS BELT, geologist and naturalist.—Born in England, 1832; died at Denver, Colorado, 1878. Made geological investigations in the Australian gold-diggings from 1852 to 1862; came to Nova Scotia as superintendent of the N. S. Gold Company's mines in 1862, and returned to England (Newcastle-on-Tyne) in 1863 or 1864; conducted the gold-mining operations of the Chontales company, Nicaragua, from 1868 to 1872. Elected a fellow of the Geological Society in 1866. He published works which chiefly relate to the glacial period (for which some of his observations were made in this province), and also his popular classic, 'The Naturalist in Nicaragua' (1874), a work which contains much information on protective mimicry, plant fertilization, sexual selection, etc., and written in a fine style. He was one of the original members of the Institute, was elected to the first and second council, and was a member until his death. He contributed four papers to the Transactions, his list of butterflies observed about Halifax, being the first such catalogue to be published. (See Dict. of Nat. Biog., iv., p. 204; also Trans N. S. I. N. S., v., p. 4.)

JOHN ROBERT WILLIS, conchologist.—Born at Philadelphia, U. S. A., 14th February, 1825, son of John and Elizabeth Willis, of Irish extraction; died at Halifax, 31st March, 1876. He came to Halifax when a child and was educated there at the National School of which in 1846 he became a teacher. In 1863 was appointed superintendent of an industrial school on its establishment at Halifax, and resigned from the National School. In 1865 he took an active part in the efforts to establish a Provincial Museum at Halifax and was a candidate for the position of curator, but in the same year became secretary of the Board of School Commissioners, Halifax, and in 1875 retired, being thereafter in poor circumstances. About 1850 he began to study our mollusca, thus becoming the first Nova Scotian conchologist, and in 1857 his first known list of our shells appeared in an obscure publication, supposed to have been 'The Church Record', followed by two other lists, all of which are very rare. He made a large and very fine collection of shells, both native and foreign, said to have consisted of over 8000 specimens, but the location of the local part is unknown, and the foreign portion is in ruins. Corresponded largely with noted conchologists of the time, and large numbers of his Nova Scotian specimens are in the great museums of the United States and elsewhere, and a small collection is in the museum of King's College, Windsor, but in a dilapidated state. In 1862 he was elected a corresponding member of the Liverpool (Eng.) Natural History and Microscopical Society, and in the next year a corresponding member of the Boston Society of Natural History. Though he possessed his weaknesses, yet he was a man who was much liked for his good qualities. He had been connected with the old N. S. Literary and Scientific Society of Halifax; and was one of the original members of the Institute of Natural Science, and was elected one of its first joint-secretaries, but seems not to have acted, and must have resigned the position before 4th May,

1863, as he then signed the only minutes he wrote, as secretary *pro tempore,* and was succeeded by W. Gossip. He finally withdrew from the society about 1869. The Transactions contain but one paper by him, on the occurrence of *Littorina littorea* on the coast of Nova Scotia (1863), and I fear that for some reason entire harmony could not have existed between him and the society. Vol. VII however contains a full account of his life, his writings, and a reprint of his rare list of Nova Scotian shells, a memorial to which I think he was justly entitled. (See Trans, vii., pp. 404-428.)

HENRY How, D. C. L., chemist, mineralogist and botanist. —Born at London, Eng., 11th July 1828, (son of Thomas How, whose wife was a Molyneux, whose ancestors had served in the old fort at Annapolis, N. S.); died at Windsor, N. S., Sunday, 28th September, 1879. He attended a private school in Beaconsfield and then studied chemistry at the Royal College of Chemistry, obtaining therefrom a certificate of proficiency. Prof. Hoffman, of that college, recommended him as assistant to the late Rt. Hon. Lord Playfair, F. R. S., then professor of chemistry at the College for Civil Engineers at Putney. His first paper, an analytical one, was read before the Chemical Society of London, and published in its Journal in 1846. He held his assistant professorship at Putney until he was appointed analytical chemist to the British Admiralty Steam Coal Enquiry, and in 1848-49 were published, as a British blue-book, his 'Analyses of Coals of Great Britain' with reports by Sir H. De la Beche and Dr. Lyon Playfair. Then he became assistant to Prof. Thomas Anderson of Edinburgh University, whom he accompanied in 1852 to Glasgow on the latter's appointment as Regius Professor of Chemistry in the University there, and was there for two years.

He came to Nova Scotia in 1854, being appointed fellow and professor of chemistry and natural history at King's College, Windsor, and about 1876, also vice-president of the

University and librarian. He filled the chair with untiring
zeal and the most distinguished ability until his death, a
period of some twenty-four years. His first paper on a Nova
Scotian subject (natro-boro-calcite in gypsum) appeared in
1857 and was rapidly followed by very many others. In 1861
he was employed by the Provincial Commissioners of the
Industrial Exhibition to make a collection of the minerals
of the province for the Nova Scotian court at the London
exhibition of the next year. This collection was awarded two
medals, one in the class of mining and one in that of educa-
tional works and appliances. He prepared a report on the
minerals, which however was not then published, but it
subsequently appeared as a series of articles, entitled 'Notes
on the Economic Geology of Nova Scotia,' in our Transactions
(1864-69), and with a similar title in the 'London, Edinburgh
and Dublin Philosophical Magazine' (1866-76). He also
prepared for the Provincial Commissioners a second collection
of our minerals for the Dublin Exhibition of 1865, which was
awarded a medal; and another (of 240 specimens to which were
added 84 specimens from the late Dr. Webster's collection), for
the Paris International Exhibition of 1867, for which honor-
able mention was awarded. The latter fine collection was
purchased by our government and incorporated in the Prov-
incial Museum in 1868. To accompany and illustrate this
set, he prepared a 'Sketch of the Mineralogy of Nova Scotia
as illustrated by the Specimens sent to the Paris Exhibition,'
for the official catalogue (1867). This was so much apprecia-
ted that it was decided to have him prepare a further report
on the subject. Thereupon he published, by authority of the
government, his chief work, 'The Mineralogy of Nova Scotia'
(Halifax, 1869), a book which is still much used and relied
upon for its fullness and accuracy. He discovered and named
several new minerals found in this province, for example,
mordenite, cryptomorphite, silicoborocalcite (which was
superseded by Dana's name Howlite, in honor of him), and

winkworthite. The total number of new minerals found by him was said to have been fourteen. He was also a good botanist and prepared an herbarium of Nova Scotian plants for the Paris exhibition of 1867, which is now in the Provincial Museum. 'Every one who had come in contact with Dr. How,' says the King's College Record (Oct. 1879), had been struck with his honesty of purpose, his great love of science, his varied literary taste. From the moment he landed in this country, fresh from the wonderful laboratories of Europe and glowing with enthusiasm for the prosecution of his favorite studies, he had lived a life of obscurity, almost of seculsion. A few there were, and only a few, who had come to appreciate his talent as an analyst, his great learning as a chemist, his industry in fields of original research.' I may add that the last sentence is true as regards this province alone, for abroad his great ability was recognized fully. I think I am right in saying that he was the first notable chemist we had; he was most likely the best analytical chemist we have had. He was a successful experimenter and his researches, I understand, resulted in the discovery of certain acids, etc. Billings named in his honor, *Phillipsia howi*, one of the last represen-tatives of the trilobites, discovered by How at Kennetcook, N. S., (Can. Naturalist, viii., 209); and Dawson in the pre-face to his Acadian Geology, and Dana in that to his Miner-ology, acknowledge indebtedness to him for valuable contrib-utions. Furthermore he was a fine German, French and Latin scholar.

He was an original member of our Institute and contributed to its Transactions 10 papers (14 if we count the separate parts of one of them), almost entirely on mineralogy and botany. Had he lived in Halifax, he would certainly have become a president of the society which he assisted so much by his labours otherwise. He was an honorary D. C. L. of King's College (1861), corresponding member of the New York Lyceum of Natural History and of the Natural History

Society of Montreal, etc. He possessed testimonials from some of the most distinguished chemists of England and France, and he had been heard to say, and no doubt rightly, that he could have become a fellow of the Royal Society because of his original research work, if he had had the money to waste on such an honour. How's principal papers and books, in general chemistry, analytical chemistry, mineralogy and botany, number over 44 items, and appeared in the Journal of the Chemical Society (London), Transactions of the Royal Society of Edinburgh, the Edinburgh New Philosophical Journal, Silliman's Journal, the London, Edinburgh and Dublin Philosophical Magazine, the Canadian Naturalist, Chemical News, our own Transactions, and elsewhere. (See King's College Record, Windsor, October, 1879, with list of 44 of his writings; introduction to his mineralogy of N. S.; also private sources.)

ANDREW DOWNS, C. M. Z. S., ornithologist.—Born in New Brunswick, New Jersey, 27th September, 1811, son of Robert and Elizabeth Downs, of Scotch parentage; died at Halifax 26th August, 1892. Settled at Halifax in 1825 and engaged in the plumbing business, but became deeply interested in birds and other animals, and their preservation and propagation, to which he finally devoted all his attention. He remembered seeing Audubon at Halifax on 27th August, 1833, and afterwards corresponded with him and other notable naturalists. From about May 1844 to May 1846, he was assistant curator of the Halifax Mechanics' Institute; and from then till about May 1847, was its curator. In 1847 he established at Dutch Village, near Halifax, the first zoological garden in America, sixteen years before the Central Park collection at New York was opened. This soon became very popular and was visited by persons of note who came to Halifax. In 1864 he visited Europe with specimens, alive and mounted, which he presented to the Zoological Gardens at London. In 1867 he was proposed as superintendent of the

Central Park menagerie, New York, under a recommendation
from Prof. S. F. Baird, and the next year went there to
assume the position, but displeased by what he considered
to be an over-abrupt reception, declined the appointment
and returned to Halifax. He then started a new zoological
garden near his earlier one, which he maintained for about
three years. A couple of years before his death, although of
venerable age, he built a museum annex to his house in Hali-
fax where he was surrounded by a large collection of native
birds. Ornithology was his chief study, and his knowledge of
our local birds was extensive, and would have been much
greater had he made a practice of keeping notes. He gave
freely of his information to others, and delighted in encourag-
ing in young people the outdoor study of nature. As an
taxidermist he possessed rare skill, being the best workman of
this kind we have ever had in Nova Scotia, and receiving
bronze medals at the London exhibitions of 1851 and 1862
and the Dublin exhibition of 1865, and a silver one at Paris
in 1867. His Paris exhibit was praised by Sir Wyville Thom-
son in the Illustrated London News. He mounted some
800 moose-heads, and specimens of his work were supplied to
various European sovereigns, and large quantities went to
various museums. He was an original member of this In-
stitute, although not taking up his membership till a year later,
and served on the council. In 1862 he was elected a corres-
ponding member of the Zoological Society of London. Owing
to his great lack of literary training, he wrote very little, but
his store of self-acquired knowledge was disseminated verbally
or by letters, and others profited by it. Had he possessed more
education and scientific training, I have no doubt the native
genius of the man would have caused him to make a more
notable record among our naturalists. Three papers by him
appeared in our Transactions—his only published work. His
'Land Birds of Nova Scotia' (Trans., I, 1865-66), was the first
full list of the kind we have, with the exception of Lt. Blakis-

.ton and Lt. Bland's shorter 'List of Birds of N. S.' (compiled by J. R. Willis) which appeared in the Smithsonian Report for 1858 (Wash., 1859, pp. 280-286), and which I suspect contained many of Downs's observations.   (See sketch of his life by H. Piers, Trans., x., p. xii., with portrait; Chas. Hallock, 'First American Zoo', Nature, N. Y., vol. 1(1891?), pp, 130-131; Chas. Hallock, 'Andrew Downs, naturalist,' Forest and Stream, N. Y., vol. 53(1899), p. 184, with portrait, p. 182; Gen. Campbell Hardy, 'Reminiscences of a Nova Scotian Naturalist, Andrew Downs,' Trans. xii. p. xi.)

JOHN HUNTER DUVAR.—Born 29th August, 1830, of Scottish-English parentage; died in Prince Edward Island, (?) January, 1899.   Educated in Scotland.   It is as a litterateur and poet that Duvar has left a name in Canada.   He contributed many papers on history, literature and art to various periodicals.   As a poet he displayed good song quality in his briefer lyrics, and in 1879 published 'The Enamoranda' and 'De Roberval,' a Canadian drama, in 1888.   In the latter years of his life he resided in Prince Edward Island, and was connected with the Dominion Department of Fisheries.   He was one of the original members of the Institute and was for a time a member of its council until he left Halifax for Prince Edward Island about 1868, and published a couple of papers in the first volume of Transactions, but had no standing as a scientist.   (Biographical notes, 'Songs of the Great Dominion').

JOHN BROOKIN YOUNG.—Born at Halifax, about 1835, eldest son of George Rennie Young and grandson of John Young ('Agricola'); lost in the 'City of Boston' which left Halifax on 25 Jan. 1870.   Was a civil engineer and practised in Halifax where he lived all his life.   He was an original member of the Institute and was its assistant, or joint secretary, from December, 1862 to October, 1864, but contributed nothing to its Transactions, and withdrew from the society sometime before 1865.

Rev. John Mocket Cramp, D. D.—Born at St. Peter's, England, 25th, July, 1796, son of Rev. Thomas Cramp, pastor of St. Peter's Baptist Church; died at Wolfville, N. S., 6th December, 1881. Was ordained in 1818, and from that year to 1825 was pastor of Dean St. Baptist Church, Southward; from 1827 to 1842 co-pastor with his father at St. Peter's; and from 1842 to 1844 was pastor at Hastings. In 1844 he came to Canada as principal of the Montreal Baptist College, Montreal, holding that position until 1851 when he was appointed president of Acadia College, Wolfville, N. S. From 1853 to 1855 he was principal of the Theological Institute, Acadia College, and from the latter year until 1869 was again president of Acadia. He was one of our original members, but contributed nothing to its Transactions although retaining his interest in its welfare.

Colonel Francis Duncan, R. A., C. B., M. P., LL. D., D. C. L.—Born 4th April, 1836; died, 1888. Graduated M. A. from Marischal College, Aberdeen and commissioned lieutenant in Royal Artillery, 24th September, 1855; served at Halifax and in Canada, 1857 to 1862; commis ioned captain in 1864 and major in 1874 Was instructor in gunnery, School of Gunnery, Shoeburyness, 1877 to 1882. Became lieutenant-colonel in 1881, and was emp oyed with the Egyptian Army from January, 1883, to November, 1885, taking an active part in the Soudan Expedition of 1884-5, commanded the artillery of the Egyptian army and employed on lines of communication and as commandant of Wady Halfa. Was mentioned in despatches, became a colonel in June 1885, received the Egyptian medal with clasp and made C. B. (1885). Was conservative member of parliament for Holborn division of Finsbury, 1885-6. Received the degree of LL.D from Aberdeen, and D. C. L. from Durham. Duncan, who was stationed at Halifax from 1857 to 1862 with Hardy, was among the names of the original members of the Institute of Natural Science, and deserves mention here only

on that account, as he seems to have then gone to Canada and could not take an active part in its proceedings, and most likely never took up his membership. (See. Dict. of Nat. Biog., Suppl. vol. ii., p. 166).

PIERCE STEVENS HAMILTON.—Born at Truro, N. S., 1826; died at Halifax, 22nd February, 1893. He matriculated at Acadia College, but did not graduate. Admitted an attorney in 1851 and a barrister in 1852, and practised at first at Truro, and afterwards at Halifax. Abandoned his profession to take up journalism, and edited the *Acadian Recorder* from 1853 to 1861. In 1863 was appointed the first Go d Commissioner of Nova Scotia and the next year his duties were extended and he became Chief Commissioner of Mines, holding office till about 1867. About 1871 he went to western Canada and re-entered journalism, but finally returned to Halifax where he died under somewhat distressing circumstances. He was elected a member of the Institute on 2nd March, 1863, served for a time in its council, and contributed three papers to its Transactions on geology and physical geography. He also published several pamphlets on other subjects. (See Morgan's Bibliotheca Canadensis; also Acadian Recorder, 22 Feb., 1893.)

WILLIAM CHAMBERLAIN SILVER.—Born at Preston, Halifax Co., Dec., 1814, son of William Nyan Silver, of Kentish extraction, who came to Nova Scotia in 1804; died at Halifax, 23rd February, 1903. Mr. Silver was a well known and philanthropic merchant of Halifax, the memory of whom is still fresh in our minds. While not at all an active worker in the field of science, he took an interest in it, and joined the Institute on 7th May, 1864. It is as a faithful officer of the society for the very long period of over thirty-five years, that he deserves notice here. He was elected its second treasurer, succeeding Capt. W. Lyttleton, on 9th October, 1867, and nominally retained the office (although in latter years deputing the work) till his death—the longest office term we

have had in the society. (See Acadian Recorder, Hfx., 24th February, 1903).

REV. DAVID HONEYMAN, D. C. L., F. G. S., F. R. S. C., geologist.—Born at Corbie Hill, Fifeshire, Scotland, in 1817; died at Halifax, 17th October, 1889. Educated at Dundee High School and the University of St. Andrews, where he devoted himself to the study of oriental languages and natural science. In 1836 he entered the United Secession Theological Hall, was licensed in 1841, and about 1846 came to Nova Scotia where he became professor of Hebrew in the Free Church College, Halifax, but resigned not long after. He subsequently took charge of the Presbyterian church at Antigonish, but as a preacher was not successful. All his spare time was given to the study of the geology of that district, the complicated formations of Arisaig having his special attention. After being a few years pastor at Antigonish, he resigned, although continuing to reside there until about 1868, and thereafter devoted himself to scientific work. He published his first paper, on the fossiliferous rocks of Arisaig, in the Transactions of the N. S. Literary and Scientific Society for 1859. He had charge of the Nova Scotian exhibits at the London International Exhibition of 1862, at the Dublin Exhibition of 1865, the Paris Exhibition of 1867, the Philadelphia Exhibition of 1876, and the London Fisheries Exhibition of 1883. For a short while in 1869 he was employed in Nova Scotia by the Geological Survey of Canada, for which he was fitted as a geologist, but had had no training as a topographer and draughtsman. J. R. Willis and he had, in 1865, presented a memorial to the government strongly advocating the establishment of a provincial museum, a matter which had come up four years previously, and the two memorialists became candidates for the position of curator. As a result of the agitation in various quarters, the Provincial Museum of Nova Scotia was founded about October, 1868, and Honeyman was placed in charge (at first, I believe, with-

out a salary), and he laboured at building up that institution until his sudden death in 1889. Honeyman joined the Institute of Natural Science on 3rd December, 1866, and in 1870 became a member of its council, and on 11th October, 1871, was elected honorary secretary (afterwards known as corresponding secretary), which position he held till his death, a period of eighteen years. He gave very much time and energy to the affairs of the society, which for a long period met in the museum, and succeeded Gossip as editor of the Transactions. His chief service to us, however, was the contribution to the Transactions of a very long series of papers, mostly on geological subjects, but latterly interspersed with some on marine zoology. Their number, no less than fifty-eight, makes him the most voluminous writer we have had. He also published a few papers elsewhere, and a small geological work called "Giants and Pigmies" (Halifax, 1887). He was a good geologist, probably the best the society has had among its ordinary members, although some of his conclusions came in for considerable criticism from certain quarters. His little tilts with Sir William Dawson will be recalled by our older members. It must be admitted, however, that his literary style lacked perspicuity and scientific precision and orderliness, which unfortunately has caused his reputation to suffer somewhat with those who only know him and his work by his writings. I have always felt that his writings do not do him the justice he deserves. His genial character we all remember well. He was a D. C. L. of King's College, Windsor, (1864), a fellow of the Geological Society of London (1862), an original fellow of the Royal Society of Canada (1882), a member of the Geological Society of France, honorary member of the Geologists' Association of London and of the Society of Science, Letters and Art (London), a corresponding member of the Society of Arts (London) and of the Horticultural Society (London), as well as an original member of the Geological Society of America, etc. He received the

Mantuan medal for scientific eminence, and various medals from the great exhibitions. (See Trans., vii., p. 313; obituary by MacGregor, Trans., vii., p. 320, with portrait.)

FREDERICK ALLISON, meteorologist.—Born at Halifax, 1835, son of Hon. Joseph Allison, (of north of Ireland descent); died at Halifax, 29th April, 1879. His family having moved to Windsor about 1845 or 1846, he entered King's College, in 1848, and received the degree of B. A. in 1851, and M. A. in 1865, later in life becoming one of the board of governors. He spent some years in the West Indies in a mercantile capacity, but afterwards returned to Halifax and later entered into the life insurance business and also became agent for the Collins estate. He married a daughter of Harry King of Windsor. In 1848 he began making observations on temperature at Windsor and on the death of Col. W. J. Myers, a private observor, in 1867, Allison took up the recording and publishing in the Institute's Transactions of careful meteorological observations made at his residence, South Park Street, Halifax, work which had previously been done by Myers. Later he joined with G. T. Kingston of the Toronto observatory, in urging upon the people and the government the need of a general meteorological service for the Dominion. This led to the establishment of such a department in 1871, and he was then appointed the first chief-meteorological agent for Nova Scotia, a position which he filled with ability and enthusiasm until his death, taking an interest in the progress of the service as he had in its inception. He was succeeded by his cousin and assistant, Augustus Allison. F. Allison joined the Institute in Feb., 1869, was Second Vice-President from October, 1874, to October 1878, and First Vice-President from then till his death. He was the chief contributor of meteorological papers to our Transactions (11 articles), and his carefully prepared annual summaries of our weather were looked forward to with interest. It is much to be regretted that these papers were not continued in our publications by

his successors. (See Trans., v., p. 5; Ann. Report. Meteor. Service of Canada, for 1879, p. v.)

AUGUSTUS ALLISON, meteorologist.—Born at Halifax, 19 April, 1837, son of Jonathan Crane Allison of the firm of Fairbanks and Allison; died at Halifax, 11th January, 1904. He had been assistant to his second cousin, Frederick Allison, and on the latter's death in April, 1879, continued the meteorological observations until he was regularly appointed chief meteorologcal agent for Nova Scotia in August following, retaining that position till his death when he was succeeded by F. P. Ronnan. In business Mr. Allison was connected with the Confederation Life Association. He married Miss Cevilla Hill. He joined the Institute on the same date as his cousin, 15th February, 1869, but contributed but one paper to its Transactions (Meteorological Register for 1880), and lacked the enthusiasm in the work which characterized his relative.

HENRY YOULE HIND, M. A., D. C. L., F. R. G. S., geologist and explorer.—Born at Nottingham, England, 1st June, 1823; died at Windsor, N. S., 9th August, 1908. Dr. Hind was a geologist with a large and well-deserved reputation, but as his connection with this Institute was but very slight, the present notice will be brief. He was educated at Leipsic and Cambridge, came to Canada in 1846, and two years later became a master in the Provincial Normal School, Toronto, and subsequently professor of chemistry and geology in Trinity College in the same place until 1864. In 1857 he became geologist to the first Red River expedition, and next year director of the Assiniboine and Saskatchewan exploring expedition, and in 1861 made explorations in the regions about Labrador, while in 1864 he made a preliminary geological survey of New Brunswick. In 1866 he took up his residence in Windsor, where he died. His reports on the gold districts of Nova Scotia are well-known and valuable, and he contributed to the publications of the Royal Geographical Society, the Geological Society, Society of Arts, and many

other scientific journals; his writings altogether being most voluminous.* He was also a keen student of history, and in other respects a remarkable man. He joined the Institute in February, 1869, and read three geological papers before it, only one of which was published. The non-publication of his paper of January 1870, 'On the Laurentian Rocks', seems to have been about contemporary with his early withdrawal from the society, and may have had something to do with it. His third paper, presented in March, 1904, was withdrawn. (See Morgan's Canadian Men and Women of the Time, 1898).

REV. GEORGE PATTERSON, D. D., LL. D., F. R. S. C., archæologist.—Born at Pictou, N. S., 30th April, 1824, son of Abram Patterson; died at New Glasgow, 26th October, 1897. Was educated at Pictou Academy, Dalhousie College, and the United Presbyterian Theological Hall, Edinburgh, being ordained in 1849. Labored for twenty-seven years as a minister at Greenhill, Pictou Co., till 1879, when he went to New Glasgow. In 1843, at age of nineteen, he is said to have established and edited the 'Eastern Chronicle' newspaper, and in 1850 he began to publish and edit the 'Missionary Register of the Presbyterian Church of N. S.,' afterwards superseded by the 'Missionary Record'. Was chiefly notable as a historian and theological biographer, being an industrious and painstaking compiler of facts, and wrote a well-known 'History of Pictou County' (1877), 'Memoir of Rev. Dr. MacGregor' (1859), 'Life of Dr. Keir' (——), 'Memorials of Johnston and Mattheson' (1864), and 'Life of Rev. John Geddie' (1882). His scientific work was subsidiary to that relating to history. A full list of his papers down to 1894, will be found in the Transactions of the Royal Society of Canada for that year. He was not elected a member of this Institute until 12th March, 1878, and published in its Transactions three papers, one describing the collection of Indian stone implements which he presented to Dalhousie College, one of a geological character, and the last descriptive of the

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*Hind's "Effect of Fishery Clauses of Treaty of Washington on Fisheries and Fishermen of B. N. A.", prepared for the Fishery Commission, Halifax, 1877, contains much compiled information regarding our fisheries.

Newfoundland dialect.   Princeton conferred on him the degree of D. D. (about 1870), and Dalhousie that of L L. D. (1896).   In 1889 he was elected a fellow of the Royal Society of Canada.   (See obituary by E. Gilpin, Trans. ix., p. xcv., with portrait; Morgan's Canadian Men and Women of the Time, 1898).

JOHN JAMES FOX.—Born at Salisbury, England, 1818; died at Montreal, September, 1899.   He studied medicine, but preferring a sea-faring life, spent many adventurous years in Egypt, Greece, the West Indies and South America.   In 1852 he was appointed by the British Government comptroller of customs and navigation laws at the Magdalen Islands, a position which he held for thirty years, and became familiarly known as the 'governor' of those islands.   For services to ship-wrecked mariners, the United States President presented to him a watch valued at $1,000.   His great knowledge of the fisheries made him a valuable witness before the Halifax fisheries commission of 1877.   After retiring about 1882 he moved to Halifax, where he resided for some years, and finally went to Montreal in about 1890.   He was characterized by modesty, bravery and humanity.   An anecdote is told of how he amputated a man's leg, when proper surgical aid was absent.   He joined the Institute in May, 1882, was for six years a member of its council (October, 1884 to October 1890), seldom missed a meeting, and continued his membership till his death.   One paper from his pen appeared in the Transactions, dealing with the currents of the Gulf of St. Lawrence and their danger to navigation (vol.vi., p. 302.) (See obituaries, Trans., x., p. xxxvi., [A. McKay], and in Halifax Herald, 15th September. 1899).

ARTHUR PETERS SILVER, sportsman-naturalist.—Born at Halifax, 9th January, 1851, son of Wm. C. Silver (q. v.); died at same place, 14th February, 1908.   Was educated at the Halifax Grammar School, Dalhousie College, and King's

College, Windsor, but did not, I believe, proceed to a degree. Became a partner in his father's dry-goods business in 1872, but retired in 1898, since when he devoted himself to farming at 'Riverbank', Preston, near Dartmouth, to sports, and literary pursuits. Was a keen lover of the rod and gun and became vice-president of the Game and Inland Fisheries Protection Society of N. S. Contributed many sporting sketches to 'The Badmington', 'Country Life', 'The Empire Review', 'World Wide', 'Chambers's Journal', etc. Also author of an interesting work entitled 'Farm, Cottage, Camp and Canoe in Maritime Canada' (1908) which appeared about the time of his death, and which should be read along with Hardy's 'Forest Life in Acadie'. He took a great interest in all that related to wild animal life, and was elected a member of the Institute in December, 1887, but retired about 1902. He published but one paper in our Transactions, a list of Nova Scotian Butterflies, a subject to which he had given considerable attention. (See Morgan's 'Canadian Men and Women of the Time,' 1912).

HUGH FLETCHER, B. A., geologist,—Born at London, England, 9th December, 1848, son of Hugh Rose Fletcher, a mining engineer of Scotch birth; died at Lower Cove, N. S., 23rd September, 1909. About 1858 he came to Montreal, a year after his father. In 1860 the family moved to the Bruce Mines in Lake Huron, and the fall of 1862, to Toronto. Educated at Toronto University, where he was a silver medallist in natural science, and otherwise distinguished himself. Became connected with the gold mines at Tangier, where his father was in charge. Joined the Geological Survey of Canada on 1st September, 1872, and took up work in the Sydney coal-fie d, and up to the time of his death, was employed in mapping and writing reports on the geology of Nova Scotia, having worked out in detail the structure of the Island of Cape Breton, and the counties of Guysborough, Antigonish, Pictou, Cumberland, Colchester, Hants, Kings and Annapolis.

He was the leading authority on our coal and iron deposits, and in fact knew more about our geology and mineral resource (excepting probably gold) than possibly any other man. His genial, kindly and extremely modest character was marked by every one who came in contact with him. His many maps and reports as well as other papers are a monument to his energy and display his great knowledge of a subject of which he had made a life-long study. He passed away in the midst of active work. He was elected a corresponding member of this Institute on 3rd March, 1891, and published three valuable papers in its later Transactions. (See The Nova Scotian, Mining Number, October, 1903, p. 59, with portrait; Journal of Mining Soc. of N. S.. vol. xv., 1910, p. 131, with excellent portrait.)

The curious may be interested in considering the foregoing list in the light of origin, as indicated by birth-place:

	Presidents.	Other Members.	Total.
Nova Scotian.................	3	8	11
English.....................	1	5	6
Scotch.....................	1	2	3
Canadian and Newfoundland..	1	2	3
United States of America.....	1*	2†	3‡
Welsh.	1	0	1
Irish......................	0	0	0
Total.................	8	19	27

* English parentage. † 1 Irish parentage. ‡ 1 Scotch parentage.

LIST OF OFFICERS, 1862 TO 1912.

Presidents.

Names.	Term of Office. From		To		No. of years.
1. Hon. Philip Carteret Hill, D. C. L., Q. C.	31 Dec.	1862	26 Oct.	1863	1
2. John Matthew Jones, F. L. S., F. R. S. C	26 Oct.	1863	8 Oct.	1873	10
3. John Bernard Gilpin, M. A., M. D., M. R. C. S........	8 Oct.	1873	9 Oct.	1878	5
4. William Gossip.....................................	9 Oct.	1878	13 Oct.	1880	2
5 John Somers, M. D.................................	13 Oct.	1880	10 Oct.	1883	3
6. Robert Morrow..................................	10 Oct.	1883	5 Aug.	1885	2
7. John Somers, M. D.................................	21 Oct.	1885	10 Oct.	1888	3
8. Prof. James Gordon MacGregor, D. SC., F. R. S., F. R. S. C..........................	10 Oct.	1888	9 Nov.	1891	3
9 Martin Murphy, C. E., D. SC., I. S. O..............	9 Nov.	1891	8 Nov.	1893	2
10. Prof. George Lawson, PH. D., F. I. C., F. R. S. C	8 Nov.	1893	10 Nov.	1895	2
11. Edwin Gilpin, Jr., LL., D., D. SC., F. G. S., F. R. S. C., I. S. O........................	18 Nov.	1895	8 Nov.	1897	2
12. Alexander McKay, M. A.......................	8 Nov.	1897	20 Nov.	1899	2
13. Alexander Howard MacKay, B. SC., LL. D., F. R. S. C.	20 Nov.	1899	24 Nov.	1902	3
14. Henry Skeffington Poole, D. SC., A. R. S. M., F. G. S., F. R. S. C..........................	24 Nov.	1902	18 Oct.	1905	3
15. Francis William Whitney Doane, C. E.............	18 Oct.	1905	11 Nov.	1907	2
16. Prof. Ebenezer MacKay, PH. D..................	11 Nov.	1907	14 Nov.	1910	3
17. Watson Lenley Bishop........................	14 Nov.	1910	11 Nov.	1912	2
18. Donald MacEachern Fergusson, F. C. S...........	11 Nov.	1912			

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

First Vice-Presidents.

Names.	Term of Office. From		To		No. of Years.
1. John Matthew Jones, F. L. S., F. R. S. C	31 Dec.	1862	26 Oct.	1863	1
2. John Bernard Gilpin, M. D......................	26 Oct.	1863	12 Oct.	1864	1
3. Capt. (now Maj. Gen.) Campbell Hardy, R. A.....	12 Oct.	1864	9 Oct.	1867	3
4. John Bernard Gilpin, M. D......................	9 Oct.	1867	12 Oct.	1870	3
5. George Lawson, PH. D., LL. D..................	12 Oct.	1870	9 Oct.	1872	2
6. John Bernard Gilpin, M. D......................	9 Oct.	1872	8 Oct.	1873	1
7. John Matthew Jones, F. L. S., F. R. S. C..........	8 Oct.	1873	14 Oct.	1874	1
8. William Gossip...............................	14 Oct.	1874	9 Oct.	1878	4
9. Frederick Allison..............................	9 Oct.	1878	29 Aprl.	1879	½
10. John Somers, M. D............................	11 Oct.	1879	13 Oct.	1880	1
11. Robert Morrow...............................	13 Oct.	1880	10 Oct.	1883	3
12. John Somers, M. D............................	10 Oct.	1883	21 Oct.	1885	2
13. William Gossip...............................	21 Oct.	1885	12 Oct.	1887	2
14. Prof. James Gordon MacGregor, D. SC., F. R. S	12 Oct.	1887	10 Oct.	1888	1
15. Martin Murphy, C. E., D. SC., I. S. O.............	10 Oct.	1888	9 Nov.	1891	3
16. Henry Skeffington Poole, D. SC., F. G. S..........	9 Nov.	1891	21 Nov.	1892	1
17. Prof. George Lawson, PH. D., LL..............	21 Nov.	1892	8 Nov.	1893	1
18. Alexander Howard MacKay, LL. D., F. R. S. C	8 Nov.	1893	12 Nov.	1894	1
19. Alexander McKay, M. A.......................	12 Nov.	1894	8 Nov.	1897	3
20. Alexander Howard MacKay, LL. D., F. R. S. C	8 Nov.	1897	20 Nov.	1899	2
21. Francis William Whitney Doane, C. E.............	20 Nov.	1899	18 Oct.	1905	6
22. Prof. Ebenezer MacKay, PH. D.................	18 Oct.	1905	11 Nov.	1907	2
23. Prof. Joseph Edmond Woodman, D. SC...........	11 Nov.	1907	8 Nov.	1909	2
24. Watson Lenley Bishop........................	8 Nov.	1909	12 Dec.	1910	1
25. Donald MacEachern Fergusson, F. C. S...........	12 Dec.	1910	13 Nov.	1911	1
26. Alexander Howard MacKay, LL. D., F. R. S. C	13 Nov.	1911	8 Oct.	1913	2
27. Arthur Stanley MacKenzie, PH. D., F. R. S. C	8 Oct.	1913	21 Oct.	1914	1

	Name	Second Vice-Presidents.	Term of Office. From	To		No. of Years.
1.	Robert Grant Haliburton, F. S. A.		31 Dec. 1862	26 Oct.	1863	1
2.	Capt. Campbell Hardy, R. A.		26 Oct. 1863	12 Oct.	1864	1
3.	John Bernard Gilpin, M. D.		12 Oct. 1864	9 Oct.	1867	3
4.	James Ratchford DeWolf.		9 Oct. 1867	8 Nov.	1869	2
5.	Prof. George Lawson, PH. D., LL. D.		8 Nov. 1869	12 Oct.	1870	1
6.	John Bernard Gilpin, M. D.		12 Oct. 1870	9 Oct.	1872	2
7.	Prof. George Lawson, PH. D., LL. D.		9 Oct. 1872	8 Oct.	1873	1
8.	James Ratchford DeWolf, M. D.		8 Oct. 1873	14 Oct.	1874	1
9.	Frederick Allison.		14 Oct. 1874	9 Oct.	1878	4
10.	Prof. George Lawson, PH. D., LL. D.		9 Oct. 1878	12 Oct.	1881	3
11.	Augustus Allison.		12 Oct. 1881	11 Oct.	1882	1
12.	Martin Murphy.		11 Oct. 1882	10 Oct.	1883	1
13.	William Gossip.		10 Oct. 1883	8 Oct.	1884	1
14.	Prof. James Gordon MacGregor, D. SC.		8 Oct. 1884	12 Oct.	1887	3
15.	Alexander Howard MacKay, B. A.		12 Oct. 1887	8 Oct.	1890	3
16.	John Somers, M. D.		8 Oct. 1890	9 Nov.	1891	1
17.	Prof. George Lawson.		9 Nov. 1891	21 Nov.	1892	1
18.	Henry Skeffington Poole, F. G. S.		21 Nov. 1892	8 Nov.	1893	1
19.	John Somers, M. D.		8 Nov. 1893	12 Nov.	1894	1
20.	Edwin Gilpin, Jr. LL. D.		12 Nov. 1894	18 Nov.	1895	1
21.	Alexander Howard MacKay, LL. D.		18 Nov. 1895	8 Nov.	1897	2
22.	Francis William Whitney Doane.		8 Nov. 1897	20 Nov.	1899	2
23.	Henry Skeffington Poole, A. R. S. M., F. G. S.		20 Nov. 1899	24 Nov.	1902	3
24.	Prof. Ebenezer MacKay, PH. D.		24 Nov. 1902	18 Oct.	1905	3
25.	Prof. Joseph Edmond Woodman, D. SC.		18 Oct. 1905	11 Nov.	1907	2
26.	Watson Lenley Bishop.		11 Nov. 1907	8 Nov.	1909	2
27.	Prof. Arthur Stanley MacKenzie, PH. D.		8 Nov. 1909	12 Dec.	1910	1
28.	Philip Albert Freeman.		12 Dec. 1910	13 Nov.	1911	1
29.	Donald MacEachern Fergusson.		13 Nov. 1911	11 Nov.	1912	1
30.	Prof. Howard Logan Bronson, PH. D.		11 Nov. 1912	8 Oct.	1913	1

Note—First and Second Vice-Presidents first so called in Oct., 1881.

Treasurers.

	Name	Term of Office. From	To		No. of Years
1.	Captain Westcote Whitchurch Lyttleton	31 Dec. 1862	9 Oct.	1867	5
	John Matthew Jones, acting Treasurer.	Sum. 1866	9 Oct.	1867	
2.	William Chamberlain Silver.	9 Oct. 1867	23 Feb.	1903	35⁴/₁₂
3.	William McKerron (Appointed by Council)	9 Mar 1903	12 Nov.	1906	3³/₁₂
4.	Joseph Baker McCarthy, B. A., M. SC	12 Nov. 1906	11 Nov.	1907	1
5.	Maynard Bowman, B. A.	11 Nov. 1907			

Corresponding Secretaries.

	Name	Term of Office. From	To		No. of Years.
1.	John Robert Willis.	31 Dec. 1862	26 Oct.	1863	1
2.	William Gossip.	26 Oct. 1863	11 Oct.	1871	8
3.	Rev. David Honeyman, D. C. L., F. G. S., F. R. S. C.	11 Oct. 1871	17 Oct.	1889	18
4.	Alexander Howard MacKay, LL. D., F. R. S. C.	8 Oct. 1890	8 Nov.	1892	2
5.	Prof. James Gordon MacGregor, D. SC., F. R. S.	8 Nov. 1892	9 Dec.	1901	9
6.	Prof. Ebenezer MacKay, PH. D.	9 Dec. 1901	24 Nov.	1902	1
7.	Alexander Howard MacKay, LL. D., F. R. S. C.	24 Nov. 1902	13 Nov.	1911	9
8.	Prof. Ebenezer MacKay, PH. D.	13 Nov. 1911			

Note—The official terms, Corresponding and Recording Secretaries, were first used in the By-Laws passed in Oct. 1884. Prior to that, these officers were called the First and Second Secretaries. Willis seems not to have acted, for the only minutes that are found of his, are those of 4 May, 1863, which are signed as "secretary *pro tem*".

Recording Secretaries.

Names	Term of Office From	To	No. of Years.
1. John Brookin Young	31 Dec. 1862	12 Oct. 1864	2
2. Alexander S. Finnie	12 Oct. 1864	9 Oct. 1865	1
(No Second Secretary)	9 Oct. 1865	9 Oct. 1872	8
3. Angus Ross	9 Oct. 1872	13 Oct. 1875	3
4. John Thomas Mellish, M. A., D. C. L.	13 Oct. 1875	12 Oct. 1881	6
5. Alexander MacKay, M. A	12 Oct. 1881	21 Oct. 1885	4
6. Simon Donald Macdonald, D. D. S	21 Oct. 1885	13 Oct. 1886	1
7. Alexander McKay, M. A	13 Oct. 1886	12 Nov. 1894	8
8. Harry Piers	12 Nov. 1894		

Note—The term Recording Secretary was first used in the By-Laws passed in Oct. 1884. Prior to that, this officer was called the Second Secretary. From Oct. 1865 to Oct. 1872, the duties of the Second Secretary were performed evidently by the First Secretary.

Librarians.

Name	Term of Office. From	To	No. of Years.
1. Adoniram Judson Denton	21 Oct. 1885	9 Oct. 1889	4
Harry Piers, Asst. Librarian	2 Nov. 1888	Jan. 1890	
2. Maynard Bowman, B. A	9 Oct. 1889	24 Nov. 1902	13
3. Harry Piers	24 Nov. 1902		

Note—A "Curator of the Museum and Library" was first constituted by the By-Law adopted in Oct. 1885.

PROCEEDINGS

OF THE

𝕹oba 𝕾cotian 𝕴nstitute of 𝕾cience,

SESSION OF 1913-1914.

ANNUAL BUSINESS MEETING.

Civil Engineering Lecture Room, Technical College, Halifax;
8th October, 1913.

THE PRESIDENT, DONALD M. FERGUSSON, in the chair.

Others members present: Dr. A. H. MacKay, Dr. H. L. Bronson, Maynard Bowman, Dr. E. Mackay, Alexander McKay, Dr. D. Fraser Harris, Donald S. McIntosh, Carleton B. Nickerson, W. McKerron, J. H. L. Johnstone, and Harry Piers.

PRESIDENTIAL ADDRESS: (1) Deceased Members; (2) Problems in Biochemistry.–By DONALD M. FERGUSSON, F.C.S., Halifax.

I take this opportunity of thanking the members of this Society for the honor conferred in electing me as President, an honor the more appreciated as during this term we have reached our jubilee as a society.

Deceased Members.

During the past year we suffered the loss of two members who have passed from this life.

GEORGE UPHAM HAY, Ph. B., M. A., D. Sc., F. R. S. C., corresponding member of this society, was born at Norton, N. B., June 18th, 1843. Starting as a journalist he became an educationist and was a power for advancement in our sister province. With Dr. A. H. MacKay, he established the *Educational Review*, which he managed and edited; and latterly he published several historical works. It was as a botanist that we knew him. He was a president of the Natural History Society, St. John, president of the Botanical Club of Canada, and member of the New England Botanical Club. In 1904 he was president of Section IV of the Royal Society of Canada. In 1902 he was elected a corresponding member of this Institute. His contributions to botany were many and varied and are found in the Transactions of the Royal Society of Canada, Bulletin of the Natural History Society, N. B., and Educational Review. He also contributed papers on education and natural science to the Proceedings of the Dominion Education Association, Educational Institute of N. B., and Educational Review.

JAMES GORDON MACGREGOR, M. A., D. Sc., LL. D., F. R. S., F. R. S. C., F. R. S. E., was a native of Halifax, N. S., being born March 31st, 1852. Educated here he obtained his B. A. at Dalhousie University in 1871 and M. A. in 1874. From hence he proceeded to Edinburgh University and to Leipzic and obtained the D. Sc. degree from London University in 1876. In the same year he became lecturer on physics at Dalhousie, changing to a like position at Clifton College, England, a year later. Coming back to Dalhousie University to take the Munro professorship of physics in 1879, he remained there until 1901 when he left to become professor of natural philosophy in Edinburgh University, succeeding his

old teacher Prof. P. G. Tait, and occupying that post until his death.

As a student at Dalhousie University he had a career unsurpassed in the history of that institution, the calendar of 1871 showing his name opposite every prize open to him, and his subsequent life was but a continuance of that appetite and capactiy for work which distinguished his early days.

While holding the position of Munro Professor of Physics at Dalhousie, he for several summers during his vacations, returned to Edinburgh to work in the larger laboratories there, and thus when Edinburgh University called him, he was no stranger, but one whose worth and value were known.

At Dalhousie University he acted as Secretary of the Faculty of Arts, and later as Secretary to the Senate, and there as in his laboratory and class rooms he was a source of inspiration to those with whom he came in contact. The same may be said of him in relation to our society which he joined in January, 1887. He was our President 1888-91, and for the work he did in this connection I must refer you to the paper on Past Presidents given at the beginning of this last session by our able Secretary, Mr. Piers.

At Edinburgh, he, during the twelve years there, developed and extended the Department of Natural Philosophy, changing the old Infirmary in Drummond Street into a well equipped physical laboratory, and his energies in that direction were only limited by lack of funds.

A foundation F. R. S. C., he was President of the mathematical and physical section of that body in 1892, was a Fellow and Councillor of the Royal Society of Edinburgh, and in 1900 was elected a F. R. S.

He contributed papers to our Society, to the Trans. Roy. Soc'y, Canada, Philosophical Magazine and the Physical Review, and was author of "Kinematics and Dynamics" (1887-1902) and "Physical Laws and Observations."

Taken suddenly ill on the morning of May 21st, 1913, he had time to call his son and died almost immediately afterwards. We deeply feel his loss, for to many of us he was a true friend. A man of unselfsh character and lovable, he devoted himself entirely to those around him, to his students, his fellow scientists and his family. Cognizant of our own loss, we can extend our sympathies to those bound by family ties, whose loss is not only that of the man but of husband and father.

Biological Chemistry.

The chief event, this session, in our society, has been the passing of the fiftieth milestone, and although a review would naturally suggest itself, yet any fair summary of our work would exceed the usual limit of the annual address. I have chosen rather to speak of a branch of chemistry that is now beginning, or rather has well begun, and that bids fair to be foremost in the field during the next half century.

Fifty years ago in 1863 Duvaine first established a connection between bacteria and disease, identifying a bacillus as the cause of anthrax. Down through the years intervening has research continued; bacteriology has grown to be one of the most important of the biological sciences, and one whose applications have immensely benefited humanity. One by one the bacteria, pathogenic and nonpathogenic, were isolated, and there followed methods of growing, staining and identification. From inoculations of filtrates from culture growths of pathogenic bacteria, physiological disturbances identical with those in the disease were observed. Immunity in varying degree had been known as a result of disease, and it was found that immunity could be obtained by inoculation of the artificial growth filtrate. Thus arrived the ideas of toxins and antitoxins which form the basis of the modern immunity theory.

Other bodies formed by bacterial infection were noted, such as lysins and agglutinins, the formation of the latter

being taken advantage of in the Widal test for typhoid infection. A vast amount of work was done on the effect of introducing into the blood stream foreign elements such as blood corpuscles of other species, albuminous bodies, e.g., serums, extract of muscle, etc. These developed antibodies, and we have now the biological blood test, precipitin test for flesh, and many others. Here we have evidence of a large number of reactions — chemical reactions—between bodies of whose composition and properties little is known. To investigate such is the work of a new individual, the biological chemist. There lies open to him a new and immense field in the chemistry and physics of life, in the science of the cell, with its protoplasmic contents and their activities.

The biochemist is a new specialist who must have a long and varied training, for so co-related are the sciences that he who would interpret aright the phenomena he observes must have the broadest foundation on which to build.

With some point of kinship to the toxins we have as cell products the Enzymes. The enzmyes of digestion and fermentation have long been known and investigated, and a host of enzymes are classed as catalysers, and much work has been done on the dynamics of reaction and the effect of activating and inhibiting agents.

Being catalysers, accelerators of reaction, they need only be, and are, present in small quantities, but they have a most important part in synthesis and degradation of organic matter in the life cycle. Up to the present it cannot be said that any enzyme has been obtained in a state of purity. Methods of purification employed destroy activity for some reason or other, so that little is known of their constitution beyond a general analysis.

Work is being done on the physics of the cell, on surface tension, osmotic pressure, etc. About two years ago Prof. MacCallum by means of a microchemical stain was able under the microscope to show the distribution of Potassium in cells,

and connecting the distribution of electrolyte with surface tension gave an explanation of muscle contraction and the associated nerve impulse. He also showed that a concentration of electrolyte, or ions, at one point in the living cell would explain why is was that cellular membranes acted differently in the organism from the way in which they act as dead membranes in the laboratory during osmotic experiments.

Last year Czapek published results on higher plant cells, which have a bearing on secretion and excretion. He found that these cells did not part with their soluble constituents in osmosis until the surrounding media had its tension lowered to .65 (water air surface-1). Red blood corpuscles and yeast cells did not give up haemoglobins and invertase respectively until the surface tension was reduced to .5.

One line of biological research that is going on at the present time, one on which much time and money has been spent, and the research which appeals most to the world at large, is the endeavor to find the cause and cure of cancer. The cell of abnormal growth presents a difficult biological problem. Here is a cell which breaks away from the mechanism controlling growth, and starts on a career of its own, like a semi-independent organism. Proliferating with increased rapidity it departs from its type also in division, showing varying abnormality in karyokinesis. After the physical chemistry of the normal cell is known, the abnormal cell will still present itself. Two new and important methods of technique have recently been announced which may aid in the solution of the problem. One is Dr Carrel's method of tissue growing *in vitro*, and the other is the method of *intra vitam* staining as shown by Prof. Goldmann before the Royal Society last year.

Let us hope the cure will be discovered long before the biochemist arrives at the scientific explanation of the cell of abnormal growth.

The rediscovery of Mendel's work in 1900 gave an impetus to scientific breeding experiments with animals and with plants Results of economic importance and scientific value have followed. Cambridge has given the English farmer cereals increased in strength and yield and immune to rust, hereditary qualities capable of being transmitted in accordance with Mendel's law of segregation. As the chemist now looks to the physicist for the constitution of his unit, the atom; so the biologist appeals for the exploration of his unit, the cell, to the biochemist. With the union of gametes we have the cell in which the problem of heredity is wrapped up; and as Dr. Schäfer has said, we must not be blind to the possibility that these transmitted qualities may be connected with specific chemical characters of the transmitted elements: in other words, that heredity is one of the questions the eventual solution of which we must look to the chemist to provide.

Miss Wheldale has recently done work on the coloring of flowers, finding chromogens supposedly derived from glucosides by hydrolysis, in which the color is developed by enzyme oxidases and peroxidases. White flowers may be of two kinds, one in which chromogens are absent and the other in which they are present, but unacted on by the enzymes. Prof. Keeble and Dr. Armstrong have investigated this subject and developed chemical tests to distinguish the two kinds of white flowers, to do which previously, breeding experiments would have been required. The significance of this is, that here we have the beginning of the chemists' work on heredity, color being a Mendelian unit-character.

Examination of the bacterial content of soils has shown their intimate connection with plant growth, and the parts played by some of these organisms have been worked out. Recent work on partial sterilisation of soils, after which the bacterial growth is much enlarged with consequent increase in crops suggests the destruction of protozoan enemies of the bacteria as the cause of increased bacterial content.

The term catalytic fertilizers has been applied to compounds of manganese, boron, zinc, etc., which when added to the soil in small doses have in cerain cases caused remarkable yields of crops.

The U. S. Dept. of Agriculture has given us a soil poisoning theory, finding di-hydroxystearic acid present in impoverished soils. Experiments at Rothampstead, England, have failed to confirm this. All these problems are still under investigation as are those of soil solutions, capillarity of soils, water level, etc., in relation to plant growth.

I have mentioned only a few of the subjects which the biological chemist is investigating, for the field of research is large indeed.

To show the growth of this new science, I may mention that Chemical Abstracts (published by American Chem. Society) for August 1908 contained 52 references to articles on biological chemistry whilst the August numbers for this year contained over 600 abstracts.

In the future the biochemist must simplify the language of immunity, replacing the present word-pictures by definite molecular formulae and equations. We look to him to isolate, find the composition of and eventually synthesize the enzymes, secretins, hormones, antitoxins and a host of other bodies. He must find out nature's secret when she manufactures in her laboratory by means of enzyme and chlorophyll the countless substances found in plant life, and must give us the enzyme or other catalyst to work at ordinary temperatures and utilise the sun's radiations going to waste around us. In short, he must solve the problem of photosynthesis. Ciamician, in his address before the International Congress of Applied Science last year, has given us a picture of the future, thus: "On the arid lands there will spring up industrial colonies without smoke and without smoke-stacks; forests of glass tubes will extend over the plains and glass buildings will rise every-where; inside of these will take place

the photo-chemical processes that hitherto have been the guarded secrets of the plants, but that will have been mastered by human industry which will know how to make them bear even more abundant fruit than nature, for nature is not in a hurry and mankind is."

After the physics and chemistry of the life processes are laid bare, after metabolism and its derangements are understood, then may come some idea of life and its origin. Present ideas of origin may be summed: (1) that life is originating even now around us, but beyond our powers of observation, (2) that life had its origin in finite time, and (3), the view of Arrhenius, that life had no origin in finite time but was coeval with matter and energy at infinite time. If the physicist destroy our notion of matter there will remain but life and energy; and it may be that that dualism is more apparent than real, for we only know life by energy change.

The Present Trend and Suggestions.

The solution of these problems necessitates long and continued research and that means time and money. I should like to see our provincial colleges so endowed as to give much more opportunity for research than at present. Sir .J. J. Thompson, regarding students, has said: "I have always been struck by the quite remarkable improvement in judgment, independence of thought and maturity produced by a year's research. Research develops qualities that are apt to atrophy when the student is preparing for examination and quite apart from the addition of new knowledge to our store it is of the greatest importance as a means of education."

Not only could we have more research for our students but our professors should be so situated as to be able to engage in research, and not be tied down attending to all the small details of college work.

A feature of our day has been the appointment of national commissions on Conservation of National Resources. The

powers of these bodies could be vastly extended to providing endowment for research and founding establishments like the Kaiser Whilhelm Institut in Germany. If civilised nations could see the absurdity of settling ethical issues by destruction of cellular tissues, large sums of money would be available for research into conserving the national resources which we use at present, and tapping those going to waste around us. We might then feel less ashamed of what future generations will think of the manner in which we squander their birthright of mine, field and forest. We have passed our fiftieth year and some of our younger members may see the centenary of our society. Then many present researches will have been finished but we can assure ourselves that the field ahead will be more expanded than we dream of.

Tonight we have reports from Museum and Science Library. Fifty years after this, I hope that commensurate with the large increase of population we see looming ahead the reports will show that each of these institutions will occupy as much space as the whole of the buildings in part of which they are now housed. The growth of such institutions but reflects the vitality of that phase of intellectual development which it is our pleasure and duty as a society, to advance, and which must be carefully fostered if we in this Province would keep pace with other peoples in deriving pleasure and profit from the search into Nature's secrets.

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The Treasurer, M. Bowman, presented his annual report, showing that the receipts for the year ending 31st September, 1913, were $1,042.43; the expenditures, $914.17; and the balance in current account, $128.26; while the reserve fund was $300.00, and the permanent endowment fund, $939.49. The report was received and adopted. Attention was drawn to the desirability of raising the permanent endowment fund to one thousand dollars, and then investing it in suitable bonds. This was referred to the Council for consideration.

The Librarian's report was presented by H. PIERS, showing that 1,763 books and pamphlets had been received by the Institute through its exchange list during the year 1912; and 1,298 have been received during the first eight months of the present year (1913). The total number of books and pamphlets received by the Provincial Science Library (with which those of the Institute are incorporated) during the year 1912, was 3,385. The total number in the Science Library on 31st December, 1912, was 48,882. Of these, 35,848 (about 73 per cent.) belong to the Institute, and 13,034 to the Science Library proper. The number of books borrowed was 440, besides those consulted in the library. No binding or purchasing was done by the library, directly, during the year, there being no regular grant for the library's support. The report was received and adopted.

D. S. McINTOSH, M. Sc., instructor in geology, Dalhousie University, delegate appointed to represent the Institute, read a report on the work of the Twelfth Session of the International Geological Congress, which was held at Toronto, Canada, from 7th to 14th August, 1913, there being 950 members enrolled and 433 in attendance. The Nova Scotian excursion, 20th to 29th July, was one of the most interesting of those held. The report was received and adopted.

It was reported that HORACE GREELEY PERRY, M. A., professor of biology, Acadia University, Wolfville, N. S., had been elected an associate member on 12th May last.

The following were elected officers for the ensuing year (1913-14):

*President,—*DONALD MACEACHERN FERGUSSON, F. C. S., *ex officio* F. R. M. S.

*First Vice-President,—*PRESIDENT ARTHUR STANLEY MAC-KENZIE, Ph. D., F. R. S. C.

*Second Vice-President,—*ALEXANDER HOWARD MACKAY, LL. D., F. R. S. C.

Treasurer,—MAYNARD BOWMAN, B. A.

Corresponding Secretary,—PROFESSOR EBENEZER MACKAY, Ph. D.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—PROFESSOR CLARENCE LEANDER MOORE, M. A., F. R. S. C.; ALEXANDER McKAY, M. A.; PROFESSOR DAVID FRASER HARRIS, M. D., C. M., D. Sc., F. R. S. E.; DONALD SUTHERLAND McINTOSH, B. A., M. Sc.; CARLETON BELL NICKER-SON, M. A.; PROFESSOR HOWARD LOGAN BRONSON, Ph. D.; and WILLIAM HARROP HATTIE, M. D.

Auditors,—WATSON LENLEY BISHOP and WILLIAM Mc-KERRON.

FIRST ORDINARY MEETING.

Civil Engineering Lecture Room, Technical College, Halifax; 10th November, 1913.

THE PRESIDENT, D. M. FERGUSSON, in the chair.

DAVID FRASER HARRIS, M. B., C. M., M. D., D. Sc., F. R. S. E., professor of physiology and histology, Dalhousie University, Halifax, read a paper "On the Existence of a Reducing Endo-Enzyme in Animal Tissues". (See Trans-actions, p. 259). The subject was discussed by the PRESI-DENT, Dr. A. H. MACKAY, PROF. MOORE, C. B. NICKERSON, and PROF. E. MACKAY.

A paper by HENRY S. POOLE, D. Sc., F. R. S. C., Guild-ford, Surrey, Eng., on "*Senecio jacobœa* and its parasite, *Callimorpha jacobœa:* the Ragwort and the Cinnabar Moth," with additional remarks thereon by the reader, was read by DR. A. H. MACKAY. (See Transactions, p. 279). The subject was discussed by DR. E. MACKAY, C. B. NICKERSON, W. MACKERRON, and others; and it was agreed that some steps should be taken to suppress such a noxious weed as the Ragwort. The matter was referred to the Council.

SECOND ORDINARY MEETING.

Civil Engineering Lecture Room, Technical College, Halifax; 19th January, 1914.

THE PRESIDENT, D. M. FERGUSSON, in the chair.

It was reported that on 28th November, STANLEY NEW-LANDS GRAHAM, B. Sc., professor of mining, N. S. Technical College, Halifax, had been elected an ordinary member, and E. CHESLEY ALLEN, Yarmouth, N. S., an associate member.

HERBERT BRADFORD VICKERY, Dalhousie University, read a paper entitled "Notes on the Analysis of 'Ironstone' from the King's Quarry, North West Arm, Halifax". (See Transactions, p. 209). The subject was discussed by the PRESIDENT, DR. E. MACKAY, C. B. NICKERSON, DR. BRONSON, DR. A. H. MacKAY, and H. PIERS; and a vote of thanks was presented to Mr. Vickery.

THIRD ORDINARY MEETING.

Civil Engineering Lecture Room, Technical College, Halifax; 16th February, 1914.

THE PRESIDENT, D. M. FERGUSSON, in the chair.

A paper by SIDNEY POWERS, Geological Museum, Harvard University, Cambridge, Mass., on "The Geology of a Portion of Shelburne County, Southwestern Nova Scotia," was read by PROF. McINTOSH. (See Transactions, p. 289). The subject was discussed by PROF. McINTOSH, the PRESIDENT, H. PIERS, and others.

A paper by FRANK W. DODD, C. E., of the Whitehead Torpedo Works, Weymouth, Eng., entitled, "Additional Notes on 'Integral Atomic Weights,'" was read by PROF. E. MACKAY, (See Transactions, p. 223). The discussion which

followed, was taken part in by the PRESIDENT, DR. A. H. MacKay, PROF. E. MACKAY, and C. B.NICKERSON.

Votes of thanks were passed to the authors of these two papers, MESSRS. POWERS and DODD.

FOURTH ORDINARY MEETING.

Civil Engineering Lecture Room, Technical College, Halifax;
9th March, 1914.

THE PRESIDENT, D. M. FERGUSSON, in the chair.

JOHN H. L. JOHNSTONE, B. Sc., demonstrator of physics, Dalhousie University, Halifax, read a paper, "On the Electrical Properties of Acetic Acid in the Solid and Liquid Phases". (See Transactions, p. 191). The subject was discussed by DR. BRONSON and PRESIDENT A. S. MAC-KENZIE.

PROFESSOR DAVID FRASER HARRIS, M. D., D. Sc., F. R. S. E., Dalhousie University, read a paper on "Coloured Thinking". (See Transactions, p. 308). The subject was discussed by the PRESIDENT, DR. E. MACKAY, PRESIDENT MACKENZIE, H. PIERS, DR. A. H. MacKay, and others.

FIFTH ORDINARY MEETING.

Civil Engineering Lecture Room, Technical College, Halifax;
20th April, 1914.

THE VICE-PRESIDENT, DR. A. H. MacKay, in the chair.

PROFESSOR L. C. HARLOW, B. Sc., Provincial Normal College, Truro, read a paper on "Analyses of Nova Scotian Soils". (See Transactions, p. 322). The subject was discussed by the CHAIRMAN, G. F. MURPHY, PROF. D. S. McINTOSH, W. McKERRON, and H. PIERS.

Sixth Ordinary Meeting.

Provincial Museum, Technical College, Halifax; 18th May, 1914.

The President, D. M. Fergusson, in the chair.

A paper by A. H. MacKay, LL. D., F. R. S. C., on "Phenological Observations in Nova Scotia, 1913", was read by title. (See Transactions, page 347).

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Harry Piers,
Recording Secretary.

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TRANSACTIONS

THE OPTICAL ACTIVATION OF RACEMIC BROMCAMPHOR
CARBOXYLIC ACID BY MEANS OF CATALYSTS: THE
SPECIFICITY OF CATALYSTS.—BY HENRY JERMAIN MAUDE
CREIGHTON, M. A., M. SC., DR. SC., *Lecturer on Physical
Chemistry,* Dalhousie University, Halifax, N. S.*

INTRODUCTION.

Methods for the resolution of racemic bodies into their
optically active components date back to the time of *Pasteur.*
In an investigation on the salt formed by racemic tartaric acid
with cinchonicine, he found that at first almost pure cinchoni-
cine l- tartrate *cyrstallised out* from solutions of the racemate,
while most of the cinchonicine d- tartrate remained behind in
the mother liquid. *Pasteur* also found, when yeast was added
to a solution of ammonium racemate, that the inactive solution
became laevo-rotatary after a time, and that finally it was
possible to separate l- tartaric acid from the liquid. In this
case the d- component is consumed *by the ferment.* By
means of yeast and other ferments, *LeBel*[1] was able to obtain
amyl- and several other alcohols in an active condition;

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1. Le Bel, J. A.; Compt. rend., **87**, 213, (1878); **89**, 312, (1879); Bull.
soc. chim., **7**, (3), 551.

Bremer[1] has split up inactive malic acid into its active components by means of cinchonine; and *Lewkowitsch*[2] has decomposed mandelic acid into its active isomers by different methods. The reverse of the method used *Pasteur* was employed by *Ladenburg*[3] in the synthesis of conine. Here a racemic base *a-* normal propyl piperidine, prepared by the reduction of *a-* allyl piperidine, was split up into its antipodes by means of an active acid. *E. Fischer*[4] in his researches in the sugar group has split up many compounds by the foregoing methods of *Pasteur*.

It is well known that the majority of the properties of antipodes are the same; for example, both generally react at the same rate. When, however, antipodes unite with another optically active body, they lose their antipode character and acquire different solubilities, rates of reaction, etc. Much use has been made of this in separating a racemic body into its optically active components. For instance, on account of the *different rates* at which an active body reacts with a racemate, it is possible to obtain a product which shows optical activity, by stopping the reaction before completion. In this manner *Markwald* and *Meth*[5] effected a partial separation of r- mandelic acid by l- menthylamine, the amide being formed by the reaction. The converse of this method has been used successfully by *McKenzie* and *Thompson*[6], who prepared optically active products by submitting the partially racemic esters, formed by the complete esterification of different acids externally compensated by optically active alcohols, to fractional hydrolysis with an inactive base.

An *asymmetric synthesis* of an active compound from a symmetric substance, whereby an optically active solvent should

1. Bremer, G. J. W.: Ber. d. deutsch. chem. Ges., **13**, 351, (1880).
2. Lewkowitsch, J.: Ber. d. deutsch. chem Ges., **16**, 1573, (1883).
3. Ladenburg, A.: Ber. d. deutsch. chem. Ges., **19**, 429, and 2518, (1881)
4. Fischer, E.: ibid. **23**, 2114, (1890).
5. Markwald, W., and Meth, R.: ibid., **38**, 801, (1905).
6. McKenzie, A., and Thompson, H. B.: Trans. Chem. Soc., **91**, 789, (1907).

play the part of a *catalyst,* was first suggested by *van't Hoff*[1]. This was an important suggestion for, in the plant and animal organisims, asymmetric bodies are being built continually from symmetric substances, the synthesis probably being brought about *by the actions of enzymes or other catalysts.*

It is well known that different substances are only acted on by particular enzymes, it being supposed that the enzyme associates itself with a particular molecular grouping of the substrate. This *"specificity"* of the *enzymes* is well seen in the action of various yeasts on disacchrides, an investigation carried out by *E. Fischer*[2], and one which led him to formulate his simile of the "lock and key" relationship. As this implies a close relationship between enzyme and substrate, such as is found in optically active opposites, it has been suggested that enzymes themselves are optically active bodies. *Dakin's*[3] investigation on the hydrolysis of optically active esters by the lipase of the liver affords support to this suggestion. He found that when an optically inactive mixture of the two esters of mandelic acid was acted on by lipase, the dextro component hydrolysed more rapidly than the laevo component; and further, that if the hydrolysis were incomplete, the residual mixture was laevo rotatary. The unequal rates of reaction of the two components can only be explained *if the enzyme is assumed to be optically active.* The work of *Fischer* and *Abderhalden*[4] on the relation of trypsin to the polypeptides, shows that trypsin, too, exhibits a marked affinity for certain optically active groups.

Attention was first called to the marked similiarity between enzymes and inorganic catalysts by *Berzelius*[5] in 1837. He pointed out that: "We have reasons, well founded on fact, to make the assertion, that in living plants and animals there take

1.   van't Hoff, J. H.:   "Die Lagerung der Atome im Raum."
2.   Fischer, E.:   Ber. d. deutsch. chem. Ges., **27**, 29 and 92, (1894).
3.   Dakin, H. D.:   Journ. of Physiol., **30**, 253, (1904).
4.   Fischer, E., and Abderhalden, E.:   Zeit. f. physiol. Chem., **46**, 52, (1905).
5.   Berzelius, J. J.:   Lehrb. d. Chem., 3. Aufl., 20-25 (1837).

place thousands of catalytic processes between tissues and fluids"; and also, "when compared with known phenomena in the inorganic world, it resembles nothing else so much as the decomposition of hydrogen peroxide under the influence of platinum, silver, or fibrin." In recent times, *Bredig*[1] has shown many striking resemblances between the enzymes and certain inorganic catalysts, such as colloidal solutions of the metals. Indeed, all recent investigations *point to the action of enzymes being catalytic.*

The asymmetric division of an inactive mixture by means of enzymes, which we may look on as catalysts, suggests the possibility of such a division being brought about with the help of *a catalyst of known chemical structure.*

Several attempts have already been made to accomplish an asymmetric division by means of a catalyst. *F. S. Kipping*[2] carried out the synthesis of benzion from benzaldehyde (with potassium cyanide), and of mandelic acid nitrile from benzaldehyde and potassium cyanide in concentrated alcoholic camphor solutions; but in these and other cases the compounds obtained were inactive. E. and O. *Wedekind*[3] allowed *menthyl* - benzly- aniline to unite with allyl- iodide in optically active solvents such as d- limonene, l- menthol, and l- chlor- methyl- menthyl- ether, but in every case the products were inactive. At *Bredig's* suggestion, the rate of decomposition of d- and l- camphorcarboxylic acid in d- and l- limonene was investigated by *Balcom*[4] who found that the isomers decomposed at the same rate.

It remained for Professor G. *Bredig* to find a *stereochemical specific catalyst.* At his suggestion *Fajans*[5] measured the *rate of decomposition of the isomeric camphorcarboxylic acids in*

1. Bredig, G.:   Biochem. Zeit., **6,** 283, (1907).
2. Kipping, F. S.:   Proc. Chem. Soc., **16,** 283, (1901).
3. Wedekind, E. and O.:   Ber. d. deutsch. chem. Ges., **41,** 456, (1908).
4. Balcolm, R. W.:   Diss. Heidelberg 1905.   Bredig and Balcolm: Ber. d. deutsch. chem. Ges., **41,** 740, (1908).
5. Fajans, K.:   Diss. Heidelberg 1910.   Zeit. f. phys. Chem., **73,** 25. (1910).

the presence of optically active bases, such as certain alkaloids. It was found *that not only was the rate of decomposition of the acid greatly accelerated by the different alkaloids,* but that the d- and l- acids decomposed at different rates. By acting on the *racemic acid* with quinine, and quinidine, and by stopping the reaction at the point where the excess of one component over the other was greatest, *Fajans was able to prepare optically active solutions of the isomeric camphors and the camphorcarboxylic acids.* This result is similar to that obtained by *Dakin*[1] through the catalytic *enzyme action* of lipase (a catalyst of unknown structure) on mandelic acid ester, and *constitutes the first example of an asymmetric division by means of a catalyst of definite structure.*

Recently, in the physical chemical institute of this place, *Bredig* and *Fiske*[2] have further brought about an *asymmetric synthesis* of a nitrile by the use of optically active catalysts. The reaction

$$C_6H_5CHO + HCN = C_6H_5CH\ OH\ CN$$
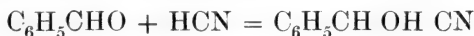
is catalysed by bases, and when *alkaloids* (in this case quinine and quinidine) are used *as catalysts* the resulting nitrile is optically active (that is the d- and l- nitrile are formed in unequal amount), and the mandelic acid produced by the saponification of the nitrile is also active. This asymmetric synthesis is analogous to that of *L. Rosenthaler's*[3] with the help of emulsin.

When solutions of *bromcamphor-carboxylic acid* are heated it is found that the acid decomposes much more rapidly than similar solutions of camphor-carboxylic acid. The decomposition takes place according to the equation:

$$C_8H_{14} < \genfrac{}{}{0pt}{}{CBrCOOH}{\underset{CO}{|}} = C_8H_{14} < \genfrac{}{}{0pt}{}{CrBH}{\underset{CO}{|}} + CO_2$$
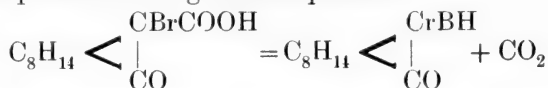
It was suggested by Professor Bredig that I should study the catalytic influence of alkaloids on the above reaction, and

1. Dakin, H. D.: loc. cit.
2. Bredig, G.: Chem. Zeitung, xxxv, 36, 324, (1911).
3. Rosenthaler, L.: Biochem. Zeit., **14**, 238, (1908).

prepared by catalysis, if possible, the optically active isomeric
bromcamphors and bromcamphor-carboxylic acids, from the
racemic bromcamphor-carboxylic acid. This acid is found to
be *much better suited* for *catalytic asymmetric division* than
camphor-carboxylic acid, for which the former acid the quantity
of catalyst, calculated in equivalents, can be *very much smaller*
than that of the decomposed *substrate*.

PREPARATIONS.

Inactive solvent: Acetophenone was obtained from C. F.
Kahlbaum, and before being used it was dried over anhydrous
sodium sulphate and redistilled.

Acids: d-, l-, and in-bromcamphor-carboxylic acids.
These acids were prepared from the corresponding camphor-
carboxylic acids. As difficulties had been experienced in
obtaining perfectly pure bromcamphor-carboxylic acids, it was
thought best to start with absolutely pure camphor-carboxylic
acids. These were prepared according to the sodium amide[1]
method of *Bruhl*[2]. The inactive acid was prepared from
synthetic camphor, (very kindly presented by the chemischen
Fabrik auf Aktien vorm. E. Schering, Berlin), after its slight
dextro rotation had been compensated by the addition of the
requisite amount of l- camphor. The best yields of camphor
carboxylic acid were obtained when the sodium amide was
finely divided, the temperature high ($110°$ — $140°$), and the
stirring as rapid as possible. It was found that the sodium
amide could be conveniently ground up in an ordinary mortar
under toluene. By using toluene or xylene for the reaction
liquid, a favourable temperature was obtained. In order to
stir the mixture rapidly, and also to lessen the chance of
breakage, owing to the tendency of the sodium amide to adhere
to the sides of the glass flask, the use of an iron vessel was tried.
It was found, howover, that the amide acted on the iron to a
certain extent, a substance resembling Prussian Blue being
formed, and that it required several crystallisations to obtain

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1. For the fresh sodium amide I am indebted to the Deutschen Gold-
und Silberscheideanstalt, Frankfort, a/M.
2. Brühl, J. W.: Ber. d. deutsch. chem. Ges., **36,** 1305, (1903).

a pure acid. The impure acids were twice recrystallised from water at 60°. In agreement with *Fajans,* the melting points of the d- and l- acids were 127° — 128°; while that of the inactive acid was higher, 136° — 137°, from which it may be concluded that the acid, prepared as above, is a racemic acid.

Analysis by titration with barium hydroxide solution and phenolphthalein gave the following degrees of purity:

	d – acid		l – acid		in acid
I	100,07%	I	100,12%	I	100,07%
II	100,11%	II	99,88%	II	100,10%
III	99,78%	III	99,98%	III	— —
Mean:	99,99%		99,99%		100,09%

The optical rotation of these camphor-carboxylic acids was determined at 25°:

3.7743 g. d- acid, dissolved to 25 ccm. in absolute alcohol, gave a rotation of + 23°.02 in a 2.5 dcm. tube.

0.4302 g. l- acid, dissolved to 10 cc. in absolute alcohol, gave a rotation of - 2°.63 in a 1 dcm. tube.

These rotations correspond to a specific rotation of ± 61°.1.

The acid prepared from the inactive camphor was completely inactive.

Besides these tests of purity the affinity constant of the d- and l- acid was measured, and the results obtained at 25° are given below[1]:

d – Camphor-carboxylic acid.				l — Camphor-carboxylic acid.			
v lit.	Mol. Cond. λ	Degree Diss. $100\,\gamma$	$\lambda \infty = 374$ 100 k	v lit.	Mol. Cond. λ	Degree Diss. $100\,\gamma$	100 k
31,32	26,56	7,10	0,0173	31,32	26,60	7,11	0,0174
62,64	36,96	9,88	0,0173	62,64	37,65	10,07	0,0180
93,97	44,92	12,01	0,0175	156,64	57,65	15,41	0,0174
156,61	57,63	15,41	0,0179	250,49	70,24	18,78	0,0173
250,58	70,91	18,96	0,0177	814,35	117,21	31,34	0,0176
	Mean:	0,0175				Mean:	0,0175

1. One half of the specific conductivity of the water was subtracted from that obtained for the solution. In the case of the d- acid ½. 4 × 10⁻⁶; and in the case of the l- acid ½. 2.7 × 10⁻⁶.

The value 0.0174×10^{-2} was obtained by Ostwald for the affinity constant of d- camphor-carboxylic acid at 25°.

The bromcamphor-carboxylic acids were prepared according to *Aschan's*[1] method of brominating the corresponding camphor-carboxylic acids, in acetic acid solution at room temperature. Aschan obtained a pure acid by crystallising once from ligroin. In spite of a large number of experiments, in which a variety of solvents were employed, I have been unable to obtain a perfectly pure bromcamphor-carboxylic acid. In ligroin the acid appeared to be almost insoluble. The purest preparations were obtained by recrystallisation from a mixture containing a large quantity of ether to a small quantity of .alcohol. About 25 grams of acid were shaken up with almost sufficient ether to dissolve it, and then alcohol was added, a few drops at a time, until the acid dissolved. The acid was then allowed to slowly crystallise out from this solution. Especially good crystals were obtained with one of the preparations of l- acid. These were examined and found to consist of a combination of the following three forms of the monoclinic system :

(i)   Vertical Prisms.   a : mb : ∞ c
(ii)   Klinodoma ∞ a : b : mc
(iii) Orthopinakoid   a : ∞ b : ∞ c

The orthopinakoid was very well developed.

Two different preparations A and B of the d- and l- acids were made and in the kinetic experiments which follow, measurements were, as a rule, made with both these preparations. Only one inactive preparation was prepared. The melting points and optical rotation of the different acids were determined; also analyses were made of the acids, both by titration with barium hydroxide solution and by estimation

1. Aschan, O.:   Ber. d. deutsch. Chem. Ges., **27**, 1445, (1894).

of the bromine content. The results obtained are given in the following table:

Preparations :	d—acid		l—acid		in acid
	A	B	A	B	
Melting Point :	$111,5°$	$111,0°$	$111,0°$	$110,5°$	$122°$
$[a]_D^{20°}$:	$+ 77,78°$	$+ 78,00°$	$- 77,80°$	$- 77,79°$	$0,00°$
Analysis with Ba(OH)$_2$:	$97,41\%$	$96,62\%$	$97,36\%$	$96,89\%$	$96,99\%$
Analysis by Bromine Estimation :	$97,56\%$	$96,90\%$	$96,94\%$	$97,42\%$	96.97%

Bases: Quinine and quinidine were obtained from C. F. Kahlbaum, and were identified by their melting points. Before being used they were dried at $110° — 120°$[1].

APPARATUS.

In order to *determine the velocity of decomposition of the bromcamphor-carboxylic acids* in solution, both with and without catalysts, the progress of the reaction with time was followed by *weighing the amount of carbon dioxide* that was liberated from the acid. The apparatus for this consisted essentially of a small glass flask, with a capacity of about 30 ccm., which was connected to two sets of soda-lime tubes by means of a three way tap. The small reaction flask was closed with a ground glass stopper through which passed two tubes, the one going within 2 mm. of the bottom of the flask; attached to the second tube was a small cooler through which tap water flowed. During the reaction the small reaction flask was immersed in a thermostat, the temperature of which was kept constant within $\pm\ 0°.05$. The liberated CO_2 was carried off by a stream of nitrogen which bubbled through the solution. The complete apparatus is shown in fig. 1. The nitrogen was contained in the gas-holder G and in the bomb B, from either of which it passed to the purifying apparatus through the three-way tap T_1. The gas was freed from traces of oxygen by means of alkaline sodium hydrosulphite in the wash bottles W_1 and W_2; then washed with potassium hydroxide solution in the wash

1. Lenz, W.: Zeit. f. anal. Chemie, **27**, 551, (1888).

bottles W_3 and W_4; and dried with concentrated sulphuric acid in W_5. The last traces of carbon dioxide were removed with soda-lime in the tube U_1. From this the nitrogen passed into the reaction flask R, where it mixed with the carbon dioxide liberated from the acid. On passing out of the reaction flask most of the solvent vapour that was carried along with the nitrogen condensed in the cooler K_1 and ran back again into the flask; the last traces of solvent vapour condensed in the three small condensors K_2, which were immersed in a freezing mixture of ice and salt. After leaving K_2 the gas passed through the three way tap T_2 to either of the sets of soda-lime tubes U_2U_3 and U_4U_5, where the carbon dioxide was absorbed. Each of these sets of tubes was connected with a soda-lime tube R_1 or R_2 and a bubble counter b_1 or b_2. The reaction flask, the coolers, and the soda-lime tubes were all attached to a small wooden frame. To immerse the reaction flask in the thermostat it was simply necessary to lower the wooden frame. At fixed times the current of gas was cut off from one set of U-tubes and passed through the second set by means of the three way tap; during the interval the first set of tubes was weighed. This operation was repeated as often as was necessary. The influence of the rate of the nitrogen stream on the velocity of decomposition of the bromcamphor-carboxylic acid was investigated, and it was found that the velocity of evolution of CO_2 apparently increased slightly with increase in the velocity of the nitrogen stream up to four liters per hour, probably owing to small traces of carbon dioxide remaining in supersaturated solution; but when the nitrogen stream was over four liters per hour, however, no further increase in the velocity of CO_2 evolution, with increase in the velocity of the nitrogen steam, was observed to occur. In the experiments which follow the current of nitrogen was usually 6-8 liters per hour. A more rapid current of gas was not used on account of the evaporation of the solvent. With a nitrogen stream of 8 liters per hour traces of acetophenone vapour were usually carried over into the first two tubes of the cooler K_2; but seldom was a trace of acetophenone ever found in the third

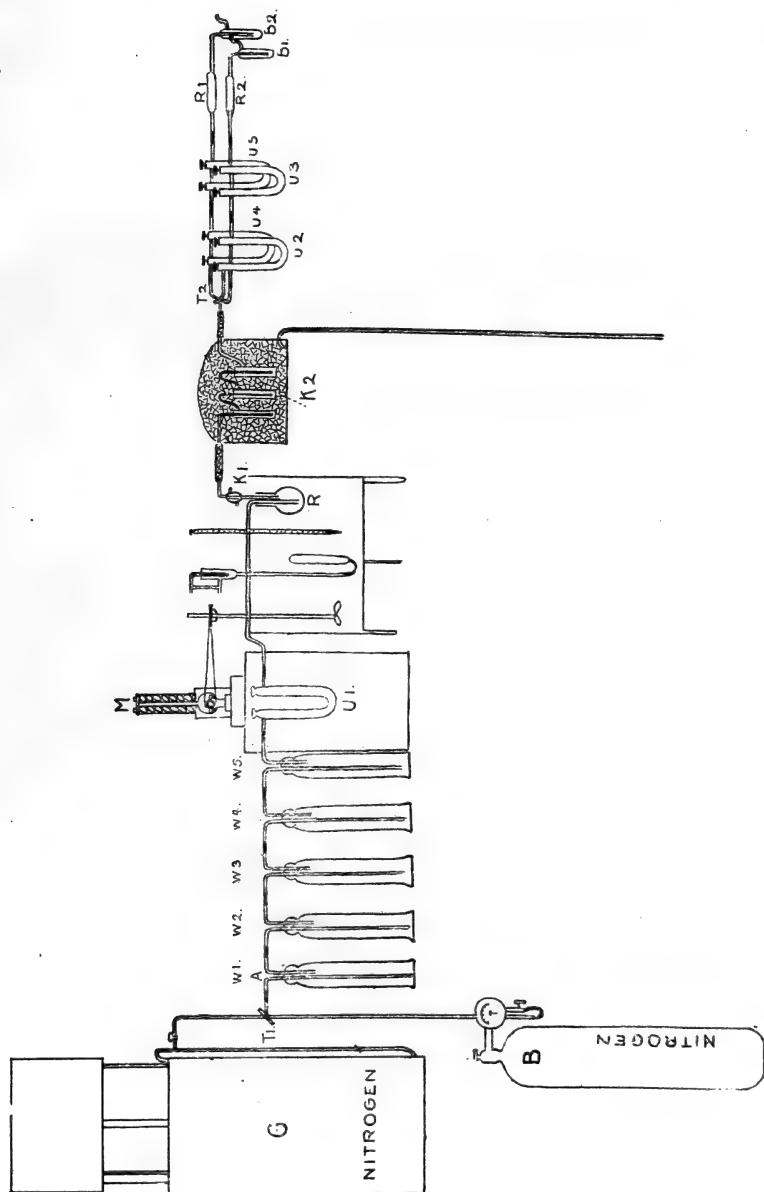FIG 1.

tube of the cooler. Owing to the fact that carbondioxide
results from the oxidation of acetophenone, it was necessary
to remove every trace of oxygen from the nitrogen. Oxidation
of acetophenone was found to take place with small traces of
oxygen at as low a temperature as $40°$. I assured myself that
the apparatus worked properly by means of a blank experi-
ment made every few days. This consisted in passing a current
of purified nitrogen through some solvent contained in the re-
action flask, and then through the soda-lime tubes. At the end of
$1/2 - 1$ hour the tubes were weighed and it was seen whether
they had increased in weight.

The efficiency of the apparatus was tested by decomposing
a known weight of $Na_2 CO_3$ with pure dilute sulphuric acid,
and the evolved CO_2 carried off with a current of dry pure
nitrogen into the soda-lime tubes, after having been dried with
concentrated sulphuric acid. The results obtained were:

0.3428 g. $Na_2 CO_3$ liberated 0.1419 g. CO_2 ;   calculated
0.1423 g.   Error: $- 0.3\%$.

As a further test of the efficiency of the apparatus the
velocity constant of decomposition of d- and l- camphor-
carboxylic acids was measured. As *Fajans* has found, the
reaction follows the first order. k has been calculated from
the formula :

$$k = \frac{1}{t \cdot 0,4343} \, \lg \frac{A}{A - x},$$

where t is the time in minutes, A the original amount of acid
calculated as CO_2 and $A - x$ the amount present at the time
t, both expressed in milligrams.

TABLE I.

Each gram of acid in 10 ccm[1]. acetophenone. Temperature 80°

d—acid			l—acid		
t	A — x	k	t	A — x	k
0	225,1	—	0	225,1	—
60	210,3	0,00113	58	211,2	0,00114
154	189,5	0,00112	180	183,7	0,00113
268	166,8	0,00112	268	166,6	0,00112
455	136,9	0,00112	420	139,1	0,00114
620	112,8	0,00111	1320	50,7	0,00113
1335	50,9	0,00111	1620	36,1	0,00113
1890	27,6	0,00111			
	Mean	0,00112		Mean	0,00113

For the d- acid Fajans[2] found k = 0.00114, and for the l- acid k = 0.00115.

On account of the relatively high rate of decomposition of bromcamphor-carboxylic acid in the presence of bases, solutions of the acid and the base were prepared separately; on starting an experiment the solution of the acid was placed in the reaction flask, nitrogen bubbled through so as to remove any carbon-dioxide and air from the apparatus, and then 1 ccm. of the solution of base, containing the required amount of the substance, was added to the acid solution in the reaction flask. The two solutions were thoroughly mixed by shaking and the flask immediately lowered into the thermostat.

1. The liquid was measured at room temperature.
2. Fajans, K.: loc. cit.

DECOMPOSITION OF BROMCAMPHOR-CARBOXYLIC ACID.

1. Experiments Without Catalysts and Temperature Co-efficient.

The decomposition of bromcamphor-carboxylic acid in acetophenone, in the absence of alkaloids, was found to follow the first order of reaction, the velocity constant being calculated from the equation

$$k = \frac{1}{t} \cdot \frac{1}{0,4343} \cdot \lg \frac{A}{A - x}.$$

The symbols here have the same meaning as previously indicated.

The values obtained for k at $80°$, $70°$, and $60°$ are as follows:

TABLE II.

Each gram of acid in 10 ccm. acetophenone.   Temperature $80°$.

d—acid			1—acid		
t	A — x	k	t	A — x	k
0	155,8	—	0	144,0	—
10	138,2	0,0120	10	127,5	0,0122
20	122,2	0,0121	20	112,9	0,0122
30	108,2	0,0122	30	100,1	0,0121
40	95,8	0,0122	40	88,9	0,0121
50	84,8	0,0122	60	70,3	0,0120
60	75,2	0,0121	85	52,7	0,0118
75	62,7	0,0121	115	35.8	0,0121
			140	27,1	0,0119
	Mean	0,0121		Mean	0,0121

TABLE III.

Each gram of acid in 10 ccm. acetophenone. Temperature 70°.

	d – acid			1 · acid	
t	A — x	k	t	A — x	k
0	160,0	—	0	160,0	—
10	152,0	0,00513	30	137,1	0,00515
30	137,3	0,00510	60	118,6	0,00499
50	124,2	0,00506	90	102,0	0,00500
80	107,1	0,00502	120	87,9	0,00499
120	88,2	0,00496	170	68,1	0,00503
240	48,5	0,00497	240	48,0	0,00502
300	35,8	0,00499			
	Mean	0,00503		Mean	0,00503

TABLE IV.

Each gram of acid in 10 ccm. acetophenone. Temperature 60°.

	d —acid			1— acid	
t	A — x	k	t	A — x	k
0	160,0	—	0	80,0	0
10	156,7	0,00207	30	75,1	0,00211
20	153,4	0,00208	60	70,3	0,00215
30	150,3	0,00208	90	65,9	0,00215
40	147,3	0,00207	150	57,7	0,00218
85	133,8	0,00210	210	50,5	0,00219
110	128,2	0,00201	380	34,9	0,00218
180	109,5	0,00211			
	Mean	0,00207		Mean	0,00216

The mean value for k is 0.0121 at $80°$, 0.00503 at $70°$, and 0.00212 at $60°$. From these numbers the temperature coefficient for two intervals of ten degrees each may be calculated. Between $60°$ and $70°$ it is 2.37 and between $70°$. and $80°$ it is 2.40.

From the van't Hoff-Arrhenius equation

$$\frac{\mathrm{dln}k}{\mathrm{dT}} = \frac{A}{T^2},$$

we obtain by integration the equation

$$\frac{1}{0,4343} \log \cdot \frac{k_1}{k_2} = \frac{A\,(T_1 - T_2)}{T_1\,T_2},$$

and from this the value for A may be calculated. By substituting the value of the ratio $\dfrac{k_{80°}}{k_{70°}}$ in the foregoing equation, A is found to be 10600, while with the ratio $\dfrac{k_{70°}}{k_{60°}}$ A is found to be 9854. The mean difference between these two values is 3.5 per cent.

2. Decomposition of Bromcamphor-carboxylic Acid at $40°$ in the Presence of Quinine and Quinidine.

a. Quinine.

Pure quinine was obtained from C. F. Khalbaum. After being dried for two hours its melting point was taken and found to be $171°.5 — 172°$.

In the following tables $\dfrac{dx}{dt}$ represents the rate of decomposition of the acid, and C_m the mean concentration of the acid; the other symbols have the same meaning previously indicated.

TABLE V.

1 g. l-acid and 0.0200 g. quinine in 11ccm. acetophenone.
(0.3305 mole acid and 0.0056 mole quinine per liter).

Experiment 1l.

t	$A - x$	$\dfrac{dx}{dt} = \dfrac{x_2 - x_1}{t_2 - t_1}$	$C_m = A - \dfrac{x_1 + x_2}{2}$	$\dfrac{\frac{dx}{dt}}{C_m} \cdot 10^2$	% Decomposition
0	160,0	—	—	—	—
10	147,9	1,21	154,0	0,79	7,6
20	134,2	1,37	141,1	0,97	16,1
30	118,9	1,53	126,6	1.21	25,5
40	101,8	1,71	110,3	1,55	36,4
50	82,1	1,97	92,0	2,14	48,7
60	60,6	2,15	71,3	3,01	62,1
70	32,5	2,81	46,6	6,03	79,7
80	27,4	0,51	30.0	1,70	82,9
100	24,3	0,15	25,9	0,51	84,8
140	21,6	0,07	22,9	0,30	86,6

Experiment 2l.

t	$A - x$				
0	160,0	—	—	—	—
5	154,9	1,02	157,5	0,64	3,2
15	142,9	1,20	148,9	0,80	10,7
25	128,3	1,46	135,6	1,08	19,8
35	112,0	1,63	120,1	1,35	30,0
45	93,8	1,82	102,9	1,77	41,1
55	72,2	2,16	83,0	2,60	54,9
65	47,7	2,45	60,0	4,08	70,2
75	24,6	2,31	36,2	6,38	84,6
85	22,7	0,19	23,6	0,80	85,8
115	21,8	0,03	22,2	0,14	86,4

TABLE VI.

1. g. d-acid and 0.0200 g. quinine in 11 ccm. acetophenone.
   (0.3305 mole acid and 0.0056 mole quinine per liter).

Experiment 31.

t	$A-x$	$\dfrac{dx}{dt}=\dfrac{x_2-x_I}{t_2-t_I}$	$C_m=A-\dfrac{x_I+x_2}{2}$	$\dfrac{dx}{dt}{C_m}\cdot 10^2$	% Experiment.
0	160,0	—	—	—	—
10	151,6	0,84	155,8	0,54	5,3
20	138,4	1,32	145,0	0,92	13,5
30	124,9	1,35	131,6	1,02	22,2
40	111,5	1,34	118,2	1,13	30,3
50	97,6	1,39	104,5	1,33	39,0
60	83,9	1,37	90,7	1,50	47,6
70	68,0	1,59	75,9	2,08	57,5
80	49,6	1,84	58,8	3,13	69,0
90	32,8	1,68	41,2	4,08	79,5
100	27,2	0,56	30,0	1,87	83,0
110	24,7	0,25	26,0	0,96	84,6
140	21,6	0,10	23,2	0,43	86,5
170	19,1	0,08	20,4	0,39	88,1

Here it is observed that the velocity of the reaction increases
with time, reaches a maxium, and then falls off rapidly to
nothing; also that the ratio of the velocity of decomposition to
the mean concentration C_m of the undecomposed acid behaves
in the same way. As should be expected, since quinine is a
laevo-rotatary substance, the rate of decomposition of the two
isomers is different. At the end of 70 minutes, when the
difference between the percentage decomposition of the two
acids is greatest (almost 25 per cent), the velocity of decom-
position of the l-acid is almost double that of the d-acid.
The progress of the reaction with time is shown in fig. 2.

b. Quinidine.

The quinidine used in the following experiments was obtained from C. F. Kahlbaum. After heating for two hours at $110° - 120°$ it melted at $170°$.

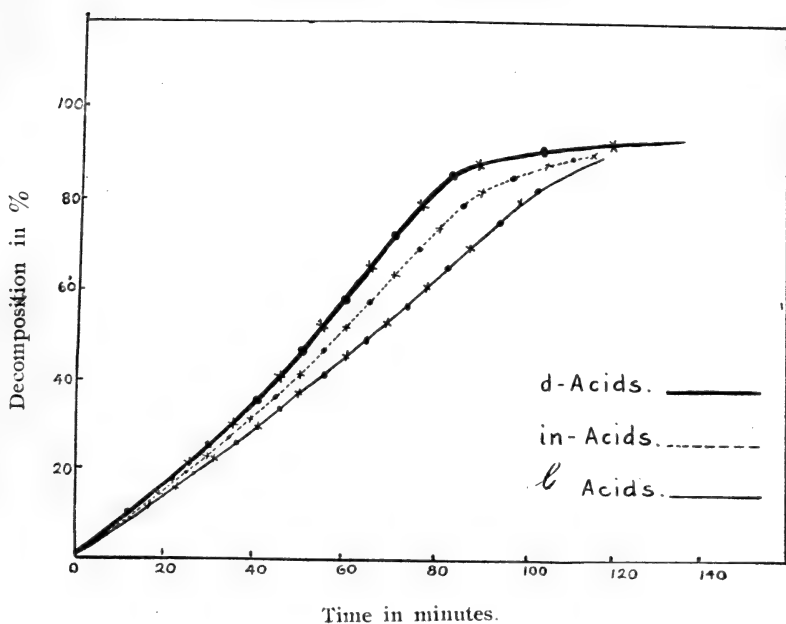### TABLE VII.

1 g. d- acid and 0.0200 g. quinidine in 11 ccm. acetophenone. (0.3305 mole acid and 0.0056 mole quinidine per liter).

Experiment 2b.

t	$A - x$	$\dfrac{dx}{dt} = \dfrac{x_2 - x_1}{t_2 - t_1}$	$C_m = A - \dfrac{x_1 + x_2}{2}$	$\dfrac{\frac{dx}{dt}}{C_m} \cdot 10^2$	% Decomposition.
0	160,0	—	—	—	—
5	155,0	1,00	157,5	0,63	3,1
15	141,7	1,33	148,4	0,89	11,4
25	128,9	1,28	135,4	0,94	19,4
35	111,9	1,70	120,4	1,42	30,1
45	94,2	1,77	103,1	1,71	41,1
55	74,8	1,94	84,5	2,29	53,3
65	54,4	2,04	64,6	3,16	66,0
75	30,6	2,38	42,5	5,60	80,9
85	18,5	1,21	24,6	4,92	88,5
115	12,4	0,20	15,5	1,29	92,3

Experiment 3b.

t	$A - x$				
0	160,0	—	—	—	—
9	149,6	1,14	154,8	0,73	6,5
20	134,2	1,54	141,9	1,08	16,1
30	119,2	1,50	126,7	1,18	25,9
40	103,1	1,61	111,1	1,45	35,6
50	85,1	1,80	94,1	1,91	46,8
60	66,1	1,90	75,6	2,51	58,7
70	43,2	2,29	54,7	4,19	73,0
80	21,4	2,18	32,3	6,75	86,5
90	16,6	0,48	19,0	2,52	89,6
100	12,1	0,45	14,4	3,12	92,5
130	8,9	0,11	10,5	1,05	94,5

FIG. 2.

Quinine as Catalyst.

Time in minutes.
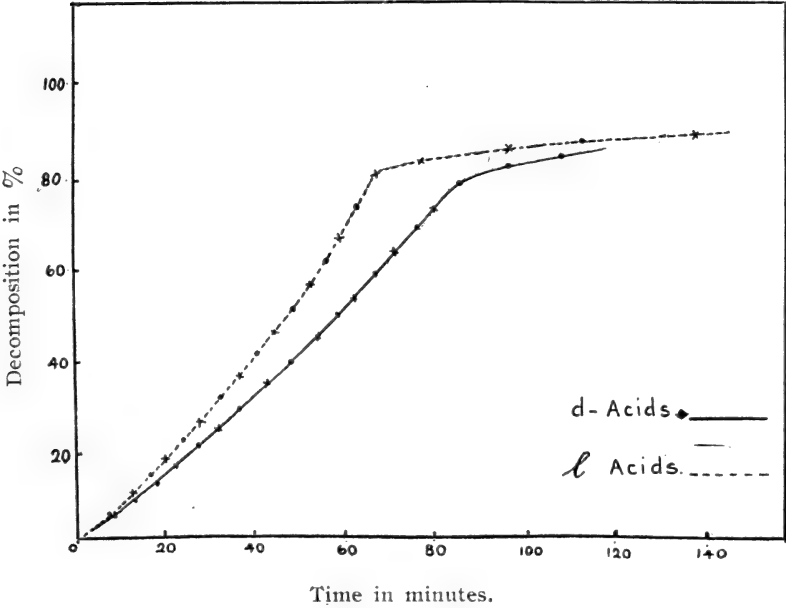
FIG. 3.

Quinidine as Catalyst.

Time in minutes.

TABLE VIII.

1 g. l-acid and 0.0200 g. quinidine in 11 ccm. acetophenone.
(0.3305 mole acid and 0.0056 mole quinidine per liter).

Experiment 4b.

t	$A - x$	$\dfrac{dx}{dt} = \dfrac{x_2 - x_1}{t_2 - t_1}$	$C_m = A - \dfrac{x_1 + x_2}{2}$	$\dfrac{\frac{dx}{dt}}{C_m} \cdot 10^2$	% Decomposition.
0	160,0	—	—	—	—
10	148,9	1,11	155,4	0,72	6,9
20	137,9	1,10	143,4	0,76	13,8
30	125,7	1,22	131,8	0,92	21,5
40	112,7	1,29	119,2	1,08	29,5
50	99,5	1,33	106,1	1,21	37,8
60	86,4	1,31	93,0	1,41	46,0
70	72.3	1,41	79,4	1,78	54,8
80	57.7	1,46	65,0	2,24	63,9
90	40,6	1,71	49,2	3,48	74,6
100	24,0	1,66	32,3	5,14	85,0
110	9,9	1,41	17,0	8,29	93,8
120	6,6	0,33	8,3	4,00	95,9
130	5,2	0,14	5,9	2,37	96,8
175	3,7	0,03	4,4	0,68	97,8

Experiment 5b.

t	$A - x$	$\dfrac{dx}{dt}$	C_m	$\dfrac{\frac{dx}{dt}}{C_m} \cdot 10^2$	% Decomposition.
0	160,0	—	—	—	—
5	154,3	1,14	157,1	0,73	3,6
15	144,5	0,98	149,4	0,66	9,7
25	132,5	1,20	138,5	0,87	17,2
35	119,6	1,29	126,1	1,02	25,2
45	104,1	1,55	111,9	1,39	34,9
55	91,1	1,30	97,6	1,32	43,1
65	78,1	1,30	84,6	1,54	51,2
75	63,7	1,44	70,9	2,03	60,2
85	46,5	1,72	55,1	3,12	71,1
95	30,4	1,61	38,4	4,19	81,0
105	14,7	1,57	20,5	7,66	90,8
125	6,8	0,40	10,8	3,70	95,8

TABLE IX.

1 g. in- acid and 0.0200 g. quinidine in 11 ccm. acetophenone. (0.3305 mole and 0.0056 mole quinidine per liter).

Experiment 6b.

t	$A - x$	$\dfrac{dx}{dt} = \dfrac{x_2 - x_1}{t_2 - t_1}$	$C_m = A - \dfrac{x_1 + x_2}{2}$	$\dfrac{\frac{dx}{dt}}{C_m} \cdot 10^2$	Decomposition.
0	160,0	---	—	—	—
10	148,3	1,17	154,2	0,75	7,3
20	136,2	1,21	142,2	0,84	14,9
30	123,0	1,32	129,6	1,02	23,1
40	107,7	1,53	115,3	1,34	32,7
50	92,3	1,54	99,0	1,55	42,3
60	75,8	1,65	84,1	1,99	52,6
79	57,3	1,85	66,6	2,77	64,2
80	39,5	1,78	48,4	3,69	75,3
90	28,2	1,13	33,9	3,33	82,4
100	19,4	0.88	23,8	3,70	87,9
110	9,0	1,04	14,5	7,32	94,4
120	3,5	0,55	6,2	8,87	97,8
130	3,0	0,05	3,3	1,51	98,1

Experiment 7b.

t	$A - x$				
0	160,0	—	--	—	—
5	153,9	1,21	157,0	0,77	3,8
15	143,5	1,04	148,7	0,70	10,3
25	130,8	1,27	137,2	0,93	18,3
35	116,5	1,43	123,7	1,15	27,2
45	100,1	1,64	108,3	1,51	37,4
55	84,6	1,55	92,3	1,68	47,1
65	67,0	1,76	78.8	2,32	58,1
75	48,2	1,88	57,6	3,27	69,9
85	33,1	1,51	40,7	3,70	79,3
95	23,7	0,94	28,4	3,33	85,2
115	6,7	0,90	14,7	6,12	96,3

An examination of the numbers in the foregoing tables shows that the influence of quinidine on the decomposition of d- and l- bromcamphor-carboxylic acid is almost identical with the effect produced by its isomer, quinine, on the decomposition of l- and d- bromcamphor-carboxylic acids. The rate of decomposition of the inactive acid lies about midway between the rates for the d- and l- acids. Further, the velocity of the reaction and the ratio given in column five of the tables show the maxium to which mention has already been made. The progress of the reaction with time is shown graphically in Fig. 3.

OPTICAL ACTIVATION BY CATALYSIS.

In the foregoing *kinetic measurements* on the decomposition of bromcamphor-carboxylic acid in the presence of quinine and quinidine, it has been found that *there is a difference between the rates of reaction of the two optical isomers.* It should be expected therefore, when the *optically inactive* acid *is decomposed under the catalytic influence of an alkaloid and the reaction stopped before the end, that the two antipodes would not be present in equivalent amounts,* and that also the *newly formed* bromcamphor, as well as the *remaining undecomposed bromcamphor-carboxylic acid, would show optical activity.* In order to test whether optical activation could be brought about by this means, *quinine* in one experiment, and *quinidine* in another were used as catalysts.

As the curves (fig. 2 and 3) illustrating the progress of the reaction with time show, the difference between the already decomposed (or still undecomposed) acid content of the two isomers grows steadily for a time, reaches a maximum, and then falls off until, when the acid is all decomposed, it is nothing as at the beginning of the reaction. In order to obtain the greatest rotation it is evident that the *reaction must be stopped at the moment when this difference is greatest.* This is readily calculated from the curves.

Synthetic camphor, the weak dextro-rotation of which was compensated with the necessary amount of l-camphor, was used to prepare a *bromcamphor-carboxylic acid* which was *completely inactive*. This acid was used for the following activation experiments.

1. With *quinine*. Since with this alkaloid the l-acid decomposes more rapidly than the d-acid, one should expect that the undecomposed acid on the one hand would be laevo-rotatary, and on the other the bromcamphor, which is formed by the reaction, would be dextro-rotatary.

From the decomposition curve it is found that the most favourable moment for stopping the reaction is at the end of 68 minutes. Two parallel experiments were made. 5.0000 grams of inactive bromcamphor-carboxylic acid were dissolved in 50 ccm. of acetophenone and mixed with 5 ccm. of aceto-phenone which contained 0.1000 gram of quinine. The mixture was placed in a thermostat and kept at 40° for 68 minutes, at the end of which time it was mixed with 10 ccm. of a dilute solution of hydrochloric acid and buried in a freezing mixture of salt and ice. The hydrochloric acid was previously saturated with common salt so as to cause the layer of the acid solution to separate from the acetophenone solution more quickly. The addition of the hydrochloric acid solution served the double purpose of stopping the reaction and removing the quinine The optical rotation of the hydrochloric acid solution, after separation from the acetophenone layer, was measured is a 1 dem. tube and found to be: — 1°.99. The acteophenone solution was shaken up twice again with 10 ccm. of the hydrochloric acid. The second HCl extract when polarised in a 1 dem. tube was found to give a rotation of — 0°.02; while the third extract gave a rotation of: 0°.00. 0.1000 gram of quinine was dissolved in 10 ccm. of the above HCl solution that was used for extracting the quinine from the reaction mixture; this when polarised in a 1 dem. tube and was found to give a rotation of — 1°.96, thus showing that one shaking with 10 ccm. of the HCl solution

was sufficient to remove the 0.1000 gram of chinin used for the activation. As further proof of the complete removal of the quinine, no green colouration was obtained on shaking the last HCl extract with bromine water and ammonia (a very delicate test for quinine). The undecomposed acid was then removed from the acetophenone by shaking with dilute potassium hydroxide solution. As water solutions separate only very slowly from acetophenone (the sp. g. is almost the same for the two), in most cases they were separated by means of a centrifugal machine. After removal of the acid the aceophenone solution was dried with anhydrous sodium sulphate. Its volume was 50 ccm., 5 ccm. having been lost in the separation operations. 16 ccm. of this solution were placed in a 2 dcm. tube and its rotation was found to be: $a = -0°.71^{*}$. In order to calculate the amount of active bromcamphor in the acetophenone solution, the specific rotation of bromcamphor in acetophenone was measured. 0.5000 gram of d- bromcamphor, dissolved to 10 ccm. in acetophenone, gave, in a 1 dcm. tube, a rotation of: $+6°.94$, corresponding therefore to $[a]_{D}^{18°} = 138°.8$. The weight of bromcamphor contained in $v = 55$ ccm. of the above acetophenone is

$$g = v \frac{a}{[a] \cdot l} = 55 \frac{0,71}{138,8 \cdot 2} = 0,141 \text{ g.}$$

From the kinetic data it is found that, at the end of 68 minutes from the commencement of the reaction, 1.569 g. of l- bromcamphor and 1.176 g. of d- bromcamphor should be found. The excess of l- bromcamphor over d- bromcamphor being, therefore 0.420 g. Perhaps the difference between the amount of active bromcamphor calculated from the kinetic data and that actually found, may be due to the occurrence of racemization.

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*The mean error in reading the polariscope was $0°.01 — 0°.02$.

The undecomposed bromcamphor-carboxylic acid was precipitated from the potassium hydroxide solution with dilute hydrochloric acid, and then purified by recrystallising from ether. 1.485 grams of the acid were obtained. This amount, dissolved to 16 ccm. in absolute alcohol, gave a rotation of: $a = 1°.29$, corresponding to $[a]_D^{18°} = + 6°.92$ when measured in a 2 dcm. tube. The specific rotation of the pure active acid in absolute alcohol is $+ 77°.8$, so therefore this preparation contains 9% active acid, whereas it should contain 27% active acid. This difference is probably due to loss during the crystallisation, or possibly to racemization. It would have been better to have polarised the potassium hydroxide solution of the acid.

2. With *quinidine.* In this case the undecomposed acid should rotate to the left and the bromcamphor, formed by the reaction, to the right. The most favourable point for stopping the reaction is found from the curve (fig. 3) to be at the end of 75 minutes, at which moment 80.9% of the d- acid and 60.2% of the l- acid has decomposed. As before two parallel experiments with 5.0000 grams of inactive acid and 0.1000 gram of quinidine, dissolved in 55 ccm. of acetophenone, were carried out at 40°. The method and procedure were the same as in the foregoing experiments.

52 ccm. of the acetophenone solution of bromcamphor were obtained, and 16 ccm. of this solution when polarised in a 2 dcm. tube gave a rotation of $+ 0°.99$, corresponding therefore to 0.196 g. of active bromcamphor in the initial 55 ccm. Calculations from the kinetic data show that 0.44 g. should have been formed. In case of no other experimental error, this difference between the experimental and theoretical quantities of bromcamphor may be regarded as caused by racemization.

The undecomposed bromcamphor-carboxylic acid was removed from the potassium hydroxide solution with dilute hydrochloric acid, and then purified. The acid obtained weighed 1.535 grams. This was dissolved to 16 ccm. in

absolute alcohol and polarised in a 2 dcm. tube. This solution gave a rotation of — 1°.59 corresponding to $[a]_D^{18°} = -8°.2$, whereas from kinetic calculations it should have been $[a]_D^{18°} = -23°.2$. The excess of active acid is therefore 0.180 gram or *0.00066 mole*, whereas it should be 0.513 gram or *0.00150 mole*. In this experiment *0.00066 equivalent of acid has been made active by the catalytic influence of 0.00060 equivalent or 0.00030 mole of quinidine.*

In order to make certain that the optical activity obtained was due to a specific catalytic action of the base and not to any error in the method employed, a controll experiment was carried out in the same manner as the activation experiment. In this experiment the quantity of materials used were the same as in the activation experiment, except that here no base was used. It was found that *neither the potassium hydroxide or aceto-phenone solutions showed the slightest optical activity on being polarised.*

We see then from these experiments that, *by means of an optically active base, it is possible to produce catalytically both active bromcamphor and bromcamphor-carboxylic acid from the inactive acid,* for 4 equivalents or 4 moles of acid have been made optically active by the help of 4 equivalents or 2 moles of base. According to the kinetic curves 2 moles of base should activate about 10 equivalents or moles of acid. But for a lack of a sufficient quantity of the inactive acid, further activation experiments would have been carried out with the object of obtaining a quantitative yield of the active bromcamphor and bromcamphor-carboxylic acid.

Is the Action of the Base Catalytic?

The question of whether the acceleration of the decomposition of bromcamphor-carboxylic acid by optically active bases is due to a catalytic influence or not, is of interest, and has been

discussed at length by Fajans[1]. In order to answer this question the exact definition of catalysis and catalyst must be considered. Ostwald, who has done so much work in this region, has defined[2] catalysis as follows: "Katalyse ist die Beschleunigung eines langsam verlaufenden chemischen Vorgangs durch die Gegenwart eines fremden Stoffes." This definition is independent of what the cause of what catalysis may be. A catalyst he defines[3] as "jeden Stoff, der ohne im Endproducte einer chemischen Reaktion zu erscheinen, ihre Geschwindigkeit verändert." This definition has been broadened by Bredig[4]: "Die Katalysatoren sind Stoffe, welche die Geschwindigkeit einer Reaktion verändern, ohne stets eine stöchiometrische äquivalente Beziehung der eventuell umgewandelten Menge des sogenannten Katalysators zu der Menge der anderen umgewandelten Substanzen, der sog. Substrate, besteht." This last definition, which includes the former, is accepted to-day by most investigators in the field of catalysis.

There has been some doubt expressed as to whether the decomposition of camphor-carboxylic acid as carried out by Fajans is a catalytic process. Objections have been made to the use of equivalent quantities of acid and base on the one hand, and to the mechanism of the reaction on the other. These criticisms have been fully answered by Fajans[5].

In our reaction it has been found that the decomposition of bromcamphor-carboxylic acid is *greatly accelerated* by the presence of *very small* quantities of base. It has further been shown[6], that the base used to catalyse the decomposition of the acid is in the same condition and present in the same amount at the end of the reaction as at the beginning; and also that it is capable of decomposing *a new quantity of acid with the same velocity as at first.*

1. Fajans, K.: loc. cit. p. 59-65.
2. Ostwald, W.: Zeit. f. phys. Chemie, **15**, 705, (1894); Lehrb. d. allgem. Chemie, 2. Aufl. (1), 2, 515, (1893).
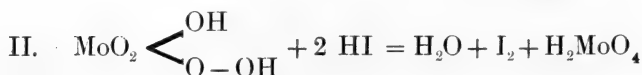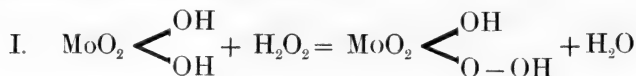3. Ostwald, W.: Zeit. f. Elektrochem, **7**, 998, (1901).
4. Bredig, G.: ibid., **9**, 735, (1903).
5. Fajans, K.: loc. cit.
6. Creighton, H. J. M.: Dissertation, Zürich, 1911, p. 30 und 74.

In the reaction under investigation, we have good reasons[1] for supposing that the acceleration in the presence of a base depends on the formation of a salt, which is much less stable than the acid itself, and which readily breaks up again into CO_2, bromcamphor, and free base, the latter being free to unite with more acid. With regard to any objections that may be raised to the theory of a catalytic action by the base, on the grounds of the mechanism of the reaction, it may be emphasized that an intermediate reaction between the acid and catalyst constitutes one of the oldest and commonest types of catalytic processes. With truth it may be held that our reaction is just as much a catalytic process as, for example, the accelerating influence of molybdic acid on the velocity of oxidation of hydriodic acid by hydrogen peroxide[2], in which reaction there takes place the following steps:

$$\text{I.} \quad MoO_2 \diagup\diagdown^{OH}_{OH} + H_2O_2 = MoO_2 \diagup\diagdown^{OH}_{O-OH} + H_2O$$

$$\text{II.} \quad MoO_2 \diagup\diagdown^{OH}_{O-OH} + 2\,HI = H_2O + I_2 + H_2MoO_4$$

We see then that the action of quinine and quinidine conforms in every way to the above definitions of catalysis, and that therefore we are justified in claiming that *our reaction is a catalytic process;* and further, *that the optical activation of the inactive bromcamphor-carboxylic acid has been accomplished by means of optically active catalysts.*

SPECIFICITY OF CATALYSTS.

The analogies between enzyme action and the action of ordinary catalysts are so numerous that the former bodies also are now generally looked on as a *type of catalyst*[3]. One of the most interesting of recently discovered analogies between these substances is to be found in their *behavior towards certain*

1. Creighton, H. J. M.: Dissertation, Zürich, 1911, p. 58 et seq.
2. Brodie, J.: Zeit. f. phys. Chemie, **37**, 257, (1901).
3. Creighton, H. J. M.: Dissertation, Zürich, 1911, p. 88 et seq.

poisons. The poisonous influence of many substances towards inorganic catalysts has been thoroughly investigated by Bredig and his pupils in the last few years. The effect of a number of different poisons on inorganic catalysts and enzymes is illustrated in the accompaning table, in which is shown the concentration of the different poisons that is necessary to entirely destroy the catalytic influence of colloidal platinum[1] and of catalase[2] on hydrogen peroxide:

Poison	Colloidal Platinum	Catalase
H_2S	1 : 300 000 molar	1 : 1 000 000 molar
HCN	1 : 20 000 000 "	1 : 1 000 000 "
$HgCl_2$	1 : 2 000 000 "	1 : 2 000 000 "
$Hg(CN)_2$	1 : 200 000 "	1 : 300 "
I in KI	1 : 5 000 000 "	1 : 50 000 "
$NH_2(OH)HCl$	1 : 25 000 "	1 : 80 000 "
Aniline	1 : 5 000 "	1 : 40 000 "
As_2O_3	1 : 50 "	1 : 2 000 "
CO	very poisonous	no paralysis
HCl	1 : 3 000 molar	1 : 100 000 "
NH_4Cl	1 : 2 000 "	1 : 1 000 "
HNO_3	no paralysis	1 : 250 000 "

That enzymes exhibit a *stereochemical specificity* has long been known. The principle here involved is that one of the antipodes of the substrate is changed much quicker by the enzyme than the other, which very often remains practically unchanged. Pasteur[3] observed, for instance, that with racemic ammonium tartrate only the dextro antipode was attacked by mould enzyme (penicillium glaucum), the solution becoming laevo-rotatary. Our fundamental knowledge in this field, however, is due to the researches of E. Fischer. He has shown that a particular enzyme is able to attack certain stereochemical

1. Bredig, G., and Müller v. Berneck: Zeit. f. phys. Chem., **31**, 258, (1899).
2. Senter, G.: Zeit. f. phys. Chem., **44**, 257, (1903).
3. Pasteur: Compt. rend., **51**, 298, (1860).

isomers which, on account of their configuration, belong to one group. Thus, for example, he has found[1] that d- glucose, d- mannose, d- galactose, and d- fructose all undergo fermentation with yeast, while the laevo isomers of these substances do not. Not only, however, are the micro-organisms able to distinguish between isomers of entirely opposed activity, but the transposition of two groups, attached to a single one of a number of asymmetric carbon atoms, is of importance to them. Fischer and Thierfelder[2] have shown that although the above mentioned sugars are fermentable by various yeasts, d- talose, which differs from d- mannose and d- galactose only by the transposition of the groups attached to a single asymmetric carbon atom, is not attacked by the same yeast species. To insure enzyme action, then, the substrate and enzyme must have their configurations adjusted to one another like lock and key; and it may be possible that they may act on one another to their mutual distruction if the keys turn opposite ways. However, experiments made by Eiloart showed no such destruction in the case of human and pig pepsins.

The relation between the substrate molecule and that of the enzyme is illustrated[3] by the splitting of a — and β — methyl

$$\begin{array}{ll}
\text{H—C—OCH}_3 & \text{H}_3\text{CO—C—H} \\
| & | \\
\text{H—C—OH} \quad \diagdown \text{O} & \text{H—C—OH} \quad \diagdown \text{O} \\
\text{HO—C—H} & \text{HO—C—H} \\
| & | \\
\text{H—C} & \text{H—C} \\
| & | \\
\text{H—C—OH} & \text{H—C—OH} \\
| & | \\
\text{CH}_2\text{—OH} & \text{CH}_2\text{—OH}
\end{array}$$
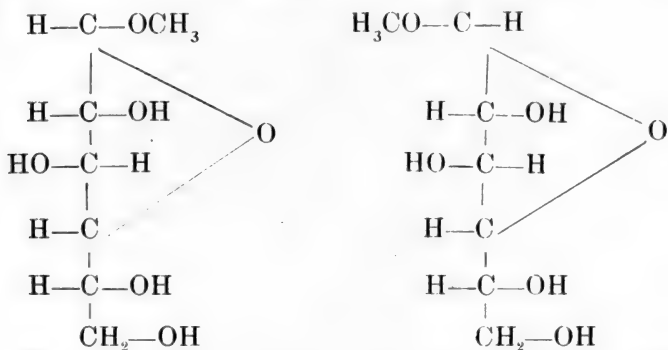
1. Fischer, E.: Zeit. f. physiol. Chem., **26**, 60, (1898).
2. Fischer, E., and Thierfelder: Ber. d. deutsch .chem. Ges., **27**, 2031, (1894); see also Fischer, ibid. **27**, 2985, 3228, 3479.
3. Fischer, E.: ibid. **32**, 3617, (1899).

glucoside into their antipodes by means of emulsin. Of these two isomers only the β- form is attacked by emulsin, which conversely this form is not changed by yeast and the a- antipode is split up into grape sugar and methyl alcohol. This "lock and key" relationship between enzyme and substrate has been confirmed by Pottevin[1] and others[2].

This *stereochemical specificity* of enzymes has been held to be a fundamental difference between the *ordinary catalysts* and the enzymes, and an important reason why the latter should not be looked on as catalysts. Very recently, however, this argument has been broken down by the investigations of Bredig and Fajans[3] whose results show *that ordinary catalysts of asymmetric structure may, like enzymes, also possess a stereochemical specificity.* The results, which I have obtained in the present investigation, *confirm and strengthen this new and important relationship between enzymes and ordinary satalysts.*

Summary.

1. The decomposition of bromcamphor-carboxylic acid in acetophenone solution has been investigated kinetically, and it has been found that the presence of small quantities of alkaloids accelerate this decomposition enormously.

2. Optically active bases catalyse the decomposition of the *antipodes* of the acid in *different degrees*. The difference between the *velocities of decomposition* of the two optical-isomeric acids is as much as 30% in some cases (Tables V and VI).

3. *This catalytic behaviour of optical active bases suggests an analogy to the stereochemical specificity of the enzymes.*

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1.   Pottevin, H.: Compt. rend., **136,** 169, (1903).

2.   For an account of the numerous investigations in this field, see Fajans, K., **loc. cit.**

3.   Fajans, K.: **loc. cit.**

4. *By means of the stereochemical specific catalytic influence of optically active bases, optically active brom-camphors, as well as optically active bromcamphor-carboxylic acids, have been prepared from inactive bromcamphor-carboxylic acid.*

5. In conclusion the specificity of catalysts has been discussed.

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Eidgenössisches Technischen Hochschule,
Zürich, Switzerland, July, 1911.

A Suggestion for Anthropological Work in Nova Scotia. —By Walter H. Prest, Bedford, N. S.

A a lover, rather than a student, of anthropology, I take upon myself the task of laying this appeal before the members of this society. The absence of a real anthropological society has been filled to a slight extent by our Nova Scotian Institute of Science, and also by a recently formed branch of the Archæological Society of America. Something has been done in ethnological research, especially by Mr. Piers who, a few years ago, read a couple of long papers before the Institute on the Indian relics now in the Provincial Museum at Halifax. At one or two county museums some Indian relics are stored which may also reveal to a critical mind their yet hidden import.

But the osteological remains of our Nova Scotia Indian are noticeable by their absence; and his physical characteristics, his relations, anthropologically speaking, with his neighbors, are confined to generalizations. Micmac anthropometry as a local study is a thing of the future. The language, customs, history, and origin of the Micmas alone is to some an interesting theme; but back of the Micmacs and their ancestry stretches a vista of possibilities in anthropology that only patient and persevering labor can open up. There on the borderland of geology lies the secret of the earliest peopling of America: and why should not the caves and clays of Nova Scotia rival the gravels of Trenton, the lavas of Idaho, or the loess of Lansing, in carrying back the antiquity of man.

There are yet many questions to answer regarding the peopling of America; pre-glacial or inter-glacial man being, I suppose, the most important and most warmly debated. Yet

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Dr. Abbott's discoveries in the gravel pits of Trenton, N. J., and the image of Nampa, Idaho, as well as the skull of Lansing, seem to bring strong, if not decisive, evidence to bear on the knotty problem. Very important evidence has also been derived from the exploration of the burial caves and mounds of America, and much otherwise curious information gathered from them. While the mounds contain almost exclusively round heads, many of the caves as well as the outlaying islands contain long heads; and yet far back of this many of the earliest men are round-headed.

There seems to have been in America, at different times, at least four or five distinct types of men among the ever moving and mingling waves of immigration: some of them including many linguistic families.

The following table, though not at all up to date, will give an approximate idea of these types. The form of the skull is indicated by the proportion of length to breadth, by length to height, and by breadth to height: called respectively, (a) the cranial index, (b) the vertical index, and (c) the parietal index. The measurements for these indices are taken as follows: For the cranial index,—distance from the glabella to the occipital point compared with the greatest parietal width. For the vertical index,—the greatest length (as in the cranial index) compared with the height from the basion to the bregma, which is the highest point in the coronal suture. For the parietal index,—the greatest parietal width compared with the basion-bregma measurement. By these and numerous other proportions is the human skull and skeleton measured and racial differences determined. In cranial indices a proportion of 74 and below compared to 100 is called dolicho-cephalic or longheaded; from 75 to 79 compared to 100 is called meso-cephalic; while from 80 and upward to 100 is called brachy-cephalic or round-headed. This list could be made more reliable by taking into consideration the discoveries of recent years, not now available;

but being approximately correct it will show some of the points
on which new evidence from Nova Scotia would be welcomed.

Tribes	Habitat	Number of skulls	Cranial Index	Vertical Index	
Very ancient graves..	Saugus, Mass.........	2	71.8	70.5	Long-heads. V. I. less than C. I.
Pre-historic cemeteries	S.Catalina Id., Mexico	38	71.8	69	
" "	S. Barbara, Cal......	49	71.8	71	
" "	S. Clemente, Cal	15	74.2	70.3	
Eskimos	Greenland	....	70.5	74.5	V. I. greater than C. I.
"	Labrador.......	....	71.8	75	
Hurons	Canada..............	74	73.6	73.3	V. I. equal to C. I.
Iroquois	New York	....	74	74	
Shell heaps............	Deer Id., Me.	2	75.3	73.4	Medium-heads. V. I. less than C. I.
Cave burials	Coahuilla, Mexico....	22	75.6	73.5	
Pre-Columbian graves	Trenton, N. J.	17	75.8	77.4	Many varied indices.
Modern indians	Mexico................	Many	76 to 78	77 to 78	
" "	United States.........	Many	77 to 82	76 to 82	
Mound builders.......	United States.........	Abt. 100	86	82	Bushman-like skulls
Very ancient.........	{ Burlington and Trenton, N. J. }	2	80.6	61	

It will be seen from the foregoing table that the mound-
builders and the Eskimo occupy extreme positions, the first
being pronounced round-heads, while the last are just as pro-
nounced long-heads.   Next to the mound builders come the
present Indians of the United States and Mexico; then follow
the historic Iroquois and Hurons and the prehistoric inhabitants
of the New England coast and Mexico, who seem to have some
affinities with the Iroquois.   There is in fact much evidence to
show that the Algonkin invasion overran a former long-headed
population somewhat closely related to the Huron-Iroquois
race, and to which the Cherokees also belonged.   Then on the
islands off the south coast of California we find prehistoric
cemeteries full of skulls of a race fully as long-headed as the
Eskimo.   At Saugus, Mass., as well as in the Florida shell-
heaps, skulls have been found resembling those of California.

But though the California, Saugus, and Eskimo skulls are all long-headed, relationship is not probable because while the Eskimo skulls show a vertical index greater than the cranial index the other skulls show the reverse.

The mound builders are so extremely round-headed as to sanction the idea that artificial distortion of the skull may have increased the average indices in the table here given. And now we come to skulls of a shape so peculiar that Prof. Hedlicka has pronounced them (at least as strong evidence of), the type of a race new to America anthropologists. I refer to the two skulls found at Trenton and Burlington, N. J., the average cranial and vertical indices of which are 80.6 and 64. While round-headed, the vertical indices are far below that of any skulls yet found in America, even among the long-heads, and thus closely resemble the Bushmen of South Africa. Their cranial capacity, however, averages a little higher than that of the Bushmen, viz. 1310 to 1270 cubic centimeters. Whether a race as low as the Bushmen ever lived in America in post-glacial times is a question yet to be answered, perhaps from Nova Scotia.

But back of this lies the presumed pre-glacial or inter-glacial man whose skulls are said to be of the long-headed type. Among the problems yet to be solved are the following:

1st. Anthropometrical study of the earliest Micmac remains.

2nd. Possible extension of long-headed races to Nova Scotia in pre-Micmac times.

3rd. The former existence in Nova Scotia of savages of the Bushmen type.

4th. The existence in Nova Scotia of a long-headed race of inter-glacial or pre-glacial age.

Grouped around these are many questions of affinity and pre-historic intercourse that we could aid in throwing light on.

When we look back on the surprising revelations given to the world by cave excavation alone, there is good reason for

the prosecution of such work in Nova Scotia. The exploration of Kents Cavern in England; of the Cave of Spy, the Caverne de l'Homme, Mort, in France; the Cave of Neanderthal in Belgium; and the gravels of the Somme, was among the chief incentives to the study of the antiquity of man a generation ago, the result of which was the placing of the study of anthropology on an entirely new footing. In the caves, kitchen-middens, and ancient burial places of Nova Scotia, many like secrets are waiting to be unveiled. Among the kitchen-middens of Nova Scotia worthy of exploration are those of Chester Basin and Musquodoboit Harbor, in which many Indian relics have been found. There are many ancient burial places, especially at Indian Gardens and Fairy Lake. Caves are known at Five-Mile River, Gay's River, and in Cape Breton, and probably other places. We have seen the advantage to anthropological science derived from the exploration of the kjokken-moddings or shell mounds of Denmark, and while those of Nova Scotia may not yield such valuable results they will amply repay investigation. The desultory digging now being carried on in these kitchen-middens, prompted by the curiosity of idle men and boys, is lessening the chances for systematic and scientific excavation as the years go by. Cave excavation though more difficult is usually more productive of results, as the contents are not so much subject to disturbance and injury by the elements. When this work is carefully carried on by experienced and conscientious explorers, by the removal, layer by layer, of the successive deposits, and the information and relics so obtained are tabulated, we should have before us a history of that particular cave or deposit, a book of nature in fact, more unimpeachable than any human literary production.

I feel strongly the lack of the latest facts on this subject, but I trust that these remarks will be taken as an evidence of my earnest wishes for the future. I shall be well satisfied if my suggestions encourage others to open up a new field of scientific research in Nova Scotia.

The Conductivity of Rosaniline Hydrochloride in Water and Certain Organic Solvents.—By Harold S. Davis, B. A., Dalhousie College.[*]

Within the last fifteen years, the knowledge of the conductivity of electrolytes in solvents, other than water, has been greatly increased. An historical summary of the work done in this field up to 1903 is given by Walden.[1]

When a solute dissolves in a solvent to form a conducting solution, the magnitude of the conductivity under given conditions of temperature and concentration depends upon (1) the solute, and (2) the solvent. But while investigation h s hitherto extended to a wide range of solvents, only a very limited number of solutes have been studied. Walden, for example, who has been the principal worker on this subject, confines his attention to tetra methyl ammonium iodide and one or two of its homologues. As regards these salts, he has shown[2] that the dissociation decreases as we advance in homologous series, that is, is greater for tetra methyl ammonium iodide than for the corresponding ethyl compound.

He has further shown empirical relations

(1) Between the dissociating power of a solvent and its dielectric constant.

(2) Between the temperature coefficient of conductivity of a solvent and the conductivity at infinite dilution.

(3) Between the dielectric constant of the solvents and the molecular dilution at which they show equal dissociation of the same salt.

1. Walden, P. : Zeitschr. f. phys. Chem., **46**, 103, (1903).
2. Walden, P. : Zeitschr. f phys. Chem , **54**, 129, (1906).

These laws having been derived from measurements of the conductivity of certain salts of the aliphatic series, the present work was undertaken in order to extend investigation to solutes containing the benzene nucleus.

The solute chosen was fuchsine.   The solvents used were water, methyl alcohol, ethyl alcohol, and acetic acid.

Some Properties of Fuchsine.   Fuchsine $C_{20}H_{20}N_3Cl$ is the hydrochloric acid salt of rosaniline (triamido di-phenyl tolyl carbinol).   It crystallizes in very small rhombic plates which are sparingly soluble in water and dissolve readly in ethyl alcohol.[1]

Like all the salts of rosaniline it is very hygroscopic, a fact which must be remembered in quantitative work.[2]

It is a powerful dye and colours the hands and dishes strongly red.   From these, however, it is easily removed by dipping in a weak solution of sodium nitrite which has been slightly acidified.   The dye is thus diazotized and may be removed by washing.

No data can be found about the melting point in Beilstein, in Thorpe's or Carnelley's tables or in any standard work of reference.   The melting point was, therefore, determined as described in this paper and found to be $216.8°C$.

The dye was also found to be readily soluble in methyl alcohol and acetic acid and fairly soluble in acetyl chloride and acetone.   It is insoluble in acetic ester.

Purification of Fuchsine.   Merck's C. P. fuchsine was recrystalized three times from water.   A sample from each was dried at 120 and a solution made, (in order to obtain complete solution of the salt, in this and all subsequent measurements, it was found necessary to warm the solution).   It was found that the conductivity decreased about ten per cent. for the first recrystallization, three for the second, and that the change for the third was inappreciable.

1. Allen, A. H. : " Commercial Organic Analysis," Vol. 3, Part I, p. 276.
2. Hoffman : Proc. Roy. Soc. **12** 2, (1862).

The final recrystallization was made from the so-called conductivity water and the sample was dried at 120°C to constant weight and preserved in a weighing tube in a desiccator.

Determination of the Melting Point of Fuchsine. The final sample was tested for its melting point. An ordinary melting point flask with sulphuric acid was used, but it was found difficult to observe the exact temperature of fusion with a capillary tube made as ordinarily described in the text books. The trouble disappeared, however, when the capillary tube, containing the fuchsine, was drawn so as to terminate in a point. Into this tube a little column of fuchsine, about 2 mm. in height was tightly packed. It was then easy to observe when the substance in the very point of the tube began to fuse. The fuchsine melted fairly sharply at 216.8°C.

The thermometer used was an ordinary one, graduated only to degrees. It was standardized by placing it in a distilling flask, containing boiling naphthalene, according to the method outlined by Gattermann in his "Laboratory Manual of Organic Chemistry," page 66.

The B. P. of naphthalene is about 217°C, the M. P. of fuchsine is about 216.8°C.

An attempt was also made to find the melting point by having the substance in a capillary tube complete an electric circuit according to the method outlined by Beilstein.[1] No change in the resistance could be detected, however, even when the substance became fused. It seems, therefore, even when fused to be a nonconductor.

Conductivity Measurements. All resistances were measured by means of the Wheatstone bridge. The bridge used was manufactured by Queen & Co. and the coils were originally (1895) guaranteed to $\frac{1}{50}$ of one per cent. and the bridge wire to $\frac{1}{100}$ of one per cent.

. Beilstein : " Organische Chemie," vol. I, page 37.

Conductivity measurements were made at three temperatures, 25°C, 18°C, and 0°C. The first two were obtained in a bath, stirred by an electric motor, and with gas supply regulated by a thermostadt. The temperature of this bath remained steady to a tenth of a degree.

The 0° bath consisted of two dishes. The outside one was filled with cracked ice, moistened with distilled water and the inner one was filled with about equal volumes of ice and water. The temperature of the cell immersed in the ice in the inner vessel remained steady at 0°C.

The cell used was about three inches in height and two in diameter. The electrodes were platinized. The constant of this cell was checked every two or three days by a standard potassium chloride solution. This solution was made from a sample prepared from Merck's C. P. chloride "for analytical purposes" by recrystallization four times from water. It was then dried in a desiccator for four or five weeks. For this sample I am indebted to Mr. C. B. Nickerson of the Chemical Department at Dalhousie College.

Preparation of Solutions. A weighed amount of fuchsine was placed in a calibrated (400 cc. or 100 cc.) flask and dissolved, and liquid added to the 400 cc. mark. It was then diluted, by the addition of pure water, to make a $\frac{1}{100}$ N. solution. In most cases the dilution required was from 2-4 cc. per 400. Some trouble and inaccuracy is caused by froth on the surface of the liquid.

20 cc. of this solution was placed by a pipette in the cell and further dilution carried out in the cell itself by two 10 cc. pipettes, one for withdrawal and one for delivery. All these pipettes were standardized.

Notation.

V = No. of liters which contain 1 mol. of dissolved solute $(C_{20}H_{20}N_3Cl = 337.4 \text{ gr.})$

τ = Temperature in Centigrade degrees.

κ° & κ^{25} = Specific conductivity of solvent (in reciprocal Siemen's units) at $\tau = 0^{\circ} - 25^{\circ}C$.

κ_1° & κ^{25} = Specific conductivity of solution (in reciprocal Siemen's units) at $\tau = 0^{\circ} - 25^{\circ}C$.

λ_{ν}^{t} = Molecular conductivity of the solution at dilution V with correction for κ the conductivity of the pure solvent.

λ_1, λ_2, etc. = corrected values of the conductivity of independent experiments.

C = temperature coefficient of the electrical conductivity for the interval $25^{\circ} - 0^{\circ}C$.

ϵ = dielectric constant at $20^{\circ}C$.

Conductivity of Fuchsine in Water. All the water used in these experiments was prepared in the usual way, either by the method of Jones and Mackay[1] or the modification of that method used by Jones and Lindsay[2].

Quite a little difficulty was experienced with either method even when the distillation was fairly slow. This difficulty was overcome by a drop catcher, so simple that it seems worth description. A four litre flask contained the original distilled water with a little sulphuric acid and potassium permanganate. From this a tube passed into a retort, containing distilled water, a little sodium hydroxide, and some permanganate. So far it is identical with the apparatus of Jones and Mackay. Into the neck of this retort was thrust that of a smaller one and the steam had finally to pass out the top of this through a tube with an expanded bulb into a block tin condenser. All the joints in the two retorts were made fairly tight with asbestos paper. Without any trouble this apparatus gave witer of conductivity $1.4 - 1.6 \times 10^{-6}$ (reciprocal Siemen's units).

In the case of water I have given the actual measurements and corrections in some detail.

The same methods are of course used throughout in all the measurements.

1. Jones, H. C. and E. Mackay : Amer. Chem., **19**, 283, (1897).
2. Jones, H. C. and C. Lindsay : Amer. Chem., **28**, 329, (1902).

Experiment 1.

κ^{25} for water $= 1.161 \times 10^{-6}$

κ^{0} for water $= 1.07 \times 10^{-6}$

v	100	200	400	800	1600	3200
$\tau = 25°$ κ_1^{25}	8.340×10^{-4}	4.316	2.191	1.109	$.5627$	$.2899$
$\kappa_{1\,corr.}$	8.324×10^{-4}	4.320	2.175	1.093	0.5466	0.2738
λ^{25}	83.24		86.00	87.00	87.44	87.46	87.62
$\tau = 0°$c.						
κ_1^{0}						0.107×10^4
$\kappa_{1\,corr.}^{0}$						0.159×10^4
λ^{0}						50.90

Experiment 2.

$\kappa_{25} = 1.161 \times 10^{-6}$

$\kappa_0 = 1.07 \times 10^{-6}$

v	100	200	400	800	1600	3200
$\tau = 25°$ κ_1^{25}	8.267×10^{-4}	4.324	2.191	1.098	0.548	0.281
$\kappa_{1\,corr.}^{25}$	8.251×10^{-4}	4.308	2.175	1.082	0.532	0.265
$\lambda_{corr.}$	82.51	86.16	87.00	86.56	85.10	84.70
$\tau = 0°$c.						
κ_1^{0}			1.202×10^{-4}	0.607	0.308	0.157
$\kappa_{1\,corr.}^{0}$			1.181×10^{-4}	0.596	0.287	0.146
λ^{0}			47.24	47.68	45.90	46.07

Experiment 3.

$\kappa^{25} = 2.00 \times 10^{-6}$

$\kappa^{18} = 1.17 \times 15^{-6}$

v	100	200	400	800	1600	3200
$\tau = 25°$ κ^{25}	8.267×10^{-4}	4.292	2.182	1.102	0.556	0.290
$\kappa^{25}_{1\,corr}$	8.247×10^{-4}	4.272	2.162	1.082	0.536	0.270
$\kappa^{25}_{1\,corr}$	82.47		85.44	85.48	86.56	85.79	86.40
κ°_1				0.592	0.300	0.152
$\kappa^{\circ}_{1\,corr}$				0.580	0.288	0.140
λ°_{corr}				46.40	46.10	44.80

Collection of results for $C_{20}H_{20}N_3$ Cl, and Water at 25°c. and 0°c.

v	100	200	400	800	1600	3200	∞
$\tau = 25$ λ^{25}_1	83.2	86.0	87.0	87.4	87.5	87.6	
λ^{25}_2	82.5	86.1	87.0	86.5	85.1	84.7	
λ^{25}_3	82.4	85.4	85.4	86.5	85.8	86.4	
Mean λ^{25}	82.7	85.8	86.5	86.8	86.1	86.2	87.0
$\tau = 0$ λ°_1						[50.9]	
λ°_2				47.6	45.9	46.7	
λ°_3			47.2	46.4	49.1	44.8	
Mean λ°			47.2	47.0	46.0	48.1	
C_{0-25}			.0375	0.539	.0348	.0318	

Mean $C_{0-25} = .0345$.

Methyl Alcohol and Fuchsine.

The methyl alcohol used was Kahlbaum's purest.

$\kappa^{25} = 5.5 \times 10^{-6}$
$\kappa^{0} = 3.9 \times 10^{-6}$

v	100	200	400	800	1600	∞
$\tau = 25°$ (1) κ_1^{25}	5.417×10^{-4}	2.938	1.573	0.825	0.435	
(2) κ_1^{25}	5.417×10^{-4}	2.953	1.561	0.835	0.445	
Mean κ_1^{25}	5.417×10^{-4}	2.945	1.667	0.830	0.440	
$\kappa_{1\,corr.}^{25}$	5.362×10^{-4}	2.890	1.512	0.775	0.385	
λ^{25}	53.6	57.8	60.5	62.0	61.6	63.5
$\tau = 0°$ (1) κ_1^{0}	3.861×10^{-4}	2.073	1.150	0.579	0.306	
(2) κ_1^{0}	3.861×10^{-4}	2.100	1.114	0.590	0.309	
Mean κ_1^{0}	3.861×10^{-4}	2.086	1.132	0.584	0.308	
$\kappa_{1\,corr}^{0}$	3.822×10^{-4}	2.047	1.093	0.545	0.269	
λ^{0}	38.22	40.9	43.7	43.6	43.0	
$C_{0—25}$	0.0161	0.0164	0.0154	0.0168	0.0172	

Mean $C_{0—25} = 0.0164$.

Ethyl Alcohol and Fuchsine.

The alcohol used was ordinary market product. It was allowed to stand with digestion over burnt lime and distilled from the same. It was then allowed to stand over dehydrated copper sulphate and distilled from this.

κ^{25} for alcohol $= 0.25 \times 10^{-6}$

κ^0 (calculated) $= 0 \ 20 \times 10^{-6}$

v	100	200	400	800	1600
$\tau = 25°$					
(1) κ_1^{25}	2.141×10^{-4}	1.175	0.6261	0.3260	0.1662
(2) κ_2^{25}	2.118×10^{-4}	1.156	0.6266	0.3222	0.1641
Mean					
κ_1^{25}	2.129×10^{-4}	1.165	0.6263	0.3241	0.1651
Mean					
$\kappa_{1\,corr}^{25}$	2.127×10^{-4}	1.163	0.6138	0.3216	01.626
λ^{25}	2.127	23.26	24.54	25.72	26.03
$\tau = 0$					$\lambda \propto = 26.0$
(1) $\kappa_1^°$	1.324×10^{-4}	0.734	0.380	0.2016	0.1032
(2) $\kappa_1^°$	1.323×10^{-4}	0.720	0.382	0.2010	0.1016
Mean $\kappa_1^°$	1.323×10^{-4}	0.727	0.381	0.2013	0.1023
Mean $\kappa_{1\,corr}^°$	1.321×10^{-4}	0.725	0.379	0.1993	0.1003
$\lambda^°$	13.21	14.50	15.15	15.94	16.04
C_{0-25}	0.0244	0.0241	0.0241	0.0244	0.0255
Mean $Co - 25 =$	0.0245				

Acetic Acid and Fuchsine.

The acetic acid used was Baker's C. P. It was purified by freezing and washing the crystals obtained thoroughly with pure acid. $\kappa^{25} = 0.53 \times 10^{-6}$.

In part of one experiment No. 2 at 25, the original acid used was $\kappa^{25} = 1.05 \times 10^{-6}$.

v	100	200	400	800	1600	∞
$\tau = 25^\circ$ $\lambda_{1\,corr}^{25}$	6.75	7.36	8.25	9.36	10.99	
$\lambda_{2\,corr}$	6.80	9.38	10.88			
Mean λ	6.77	8.37	9.60	9.30	10.99	12.5
$\tau = 18^\circ$ $\lambda_{1\,corr}^\circ$	5.94	6.16	6.88	[9.28]	8.64	
$\lambda_{2\,corr}^\circ$	5.73	6.14	7.04	8.00		
Mean λ°	5.83	6.15	6.96	8.64	8.64	

Conclusions.

The main conclusion drawn from the preceding work, is that the presence of the benzene nucleus in the solute does not make any marked difference in its behaviour as an electrolyte from that of a solute which does not contain the nucleus.

With reference to the first of the three laws enumerated by Walden, that is the well known Nernst-Thompson hypothesis, the following table shows that the amount of dissociation of fuchsine, an aromatic solute, in a solvent stands in some marked relation to the dielectric constant of the solvent. This is exactly what Walden found in the case of tetra methyl

ammonium iodide an aliphatic solute, as the following comparative table shows:

Solvent	Dielectric Constant	Dissociation at $v = 100$ Fuchsine N $(C H_3)_4 I$	
Water	81.7	95%	91%
Methyl Alcohol	32.5 — 34.8	84%	73%
Ethyl Alcohol	21.7 — 27.4	81%	54%
Acetic Acid	6.46	53%	...

The other empirical relations which Walden himself has worked out are those:

(2) Between the temperature coefficient of conductivity and the conductivity of infinite dilution.[1]

(3) Between the dielectric constants of the solvents and the molecular dilutions at which they show equal dissociation of the same solute.

I have been unable to find these relations for the conductivity of rosaniline hydrochloride in the four solvents used, and indeed it would not be permissible to draw any conclusion with such a limited number of solvents.

The following table shows the general similarity in the conductivity of solutions of the aliphatic and aromatic solutes.

Solvent	Fuchsine N $(C H_3)_4 I$ λ_∞^{25}		Fuchsine N$(C H_3)_4 I$ C_{0-25}	
Water	87	...	0.036	.....
Methyl Alcohol	63.5	124	0.016	0.015
Ethyl Alcohol	26.2	60	0.024	0.023
Acetic Acid	12.5	5.6	.....	.....

1. It is worthy of note that in calculating the temperature coefficient between 15° and 25° Walden does not use the temperature coefficient c as he has previously defined it

$$c = \frac{\lambda_v^\tau - \lambda_v^\circ}{\lambda_v^\circ \tau} \text{ but as } c = \frac{\lambda_v^{25} - \lambda_v^{15}}{\lambda_v^{15} 10}$$

This, of course, does not amount to the same thing. If the temperature coefficient of his acetic-acid solutions is calculated as first defined, it is found to be above .36 instead of .056 and this value when multiplied by the conductivity at infinite dilution 5.6 gives a constant 2.0 which is near the value of 1.3 required according to his empirical law.

Ostwald's dilution law holds fairly well for the more concentrated solutions of fuchsine in methyl and ethyl alcohols, and acetic acid.

The following table gives the value of a for these three solvents where a is defined as—

$$a = \frac{\dfrac{\lambda\nu}{\lambda x}}{\left(1 - \dfrac{\lambda\nu}{\lambda x}\right)\nu}$$

ν	Methyl Alcohol a	Ethyl Alcohol a	Acetic Acid a
100	4.60	3.48	0.615
200	4.79	3.56	0.680
400	4.83	3.42	0.635
800	4.75	(6.00)	(0.270)

It does not hold for the solutions in water, nor should we expect it to since at even the greatest concentration used, the salt was about 95% dissociated.

This investigation was suggested and carried out under the direction of Prof. E. Mackay, and I wish to take this opportunity of gratefully acknowledging his advice and kindly criticism.

DALHOUSIE UNIVERSITY,
March 8th, 1911.

Comparison of Monthly Mean Temperatures, Halifax, N. S and Plymouth, G. B. — By Henry S. Poole, D. Sc., F. R. S. C., Guildford, England.
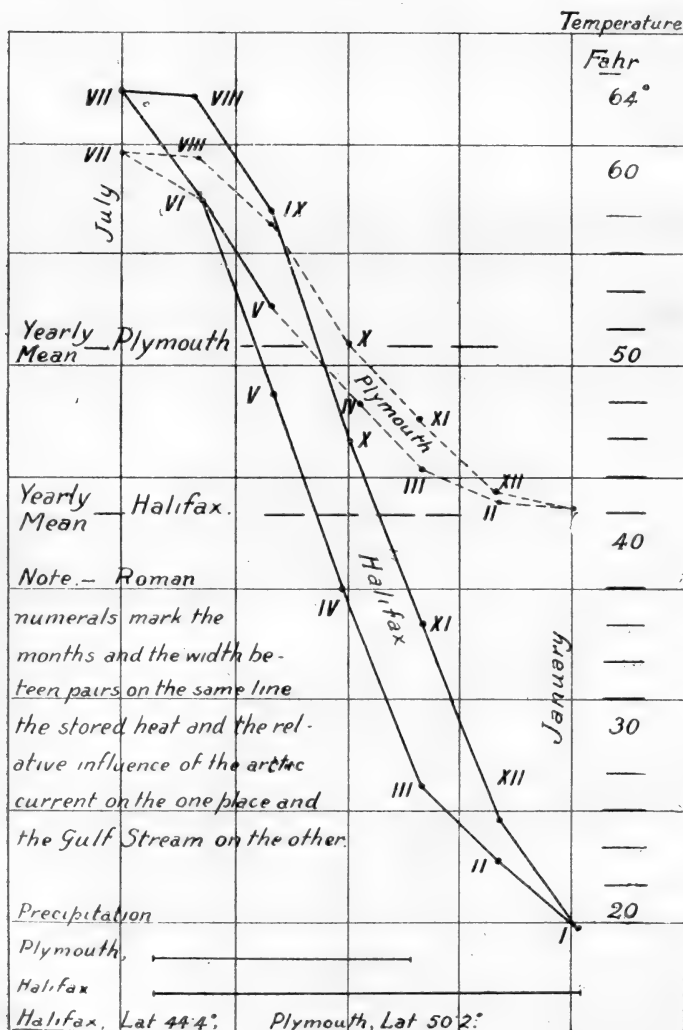
RECENT METEOROLOGICAL NOTES.—BY F. W. W. DOANE,
M. CAN. SOC. C. E., *City Engineer,* Halifax, N. S.

Dr. H. S. Poole's comparison of the monthly mean temperatures of Halifax, Nova Scotia, and Plymouth, England, tempts the writer to add a few comparatively unimportant notes.

Although the latitude of Plymouth is six degrees further north than that of Halifax, the mean temperature of Plymouth for the month of January is 42 deg. F., while that of Halifax is only 20 deg. F., a difference in favor of the higher latitude of 22 deg. During the month of June, the mean temperature in the two cities is about the same, 59 deg. F. During July and August, the mean temperature at Plymouth is between 61 deg. and 62 deg. F., while at Halifax it has risen above 64 deg. F., as it should. For the month of September the records show again about the same mean temperature for the two places, 58 deg. F. During October, November and December, however, while the mean temperature at Plymouth drops 16 deg. F., at Halifax it drops 38 deg. F.

The diagram prepared by Dr. Poole illustrates clearly the great advantage that the English city receives from the Gulf Stream, and the great disadvantage that the Nova Scotia capital labors under in consequence of its location in the path of the Arctic current. The yearly mean temperature for Plymouth is 51 deg. F., that for Halifax, 42 deg. F.

The mean temperature in Halifax for March as shown by Dr. Poole, is about 27 deg. F. For March, 1911, it was 28.85. Rain was recorded on eight days. The total precipitation was 4.086 inches, while the mean is 5.325. The weather during the first part of the month was generally cold and cloudy. The wind movement was greater than usual, with prevailing directions of northeast, southwest, northwest, west and north in the

(53)

order named. During the last days of the month, southeast gales prevailed.

Robins were reported on the 26th and wild geese on the 18th. On the 1st and 7th the temperature dropped to 1 deg. F., on the 4th 7 deg. was registered, 6th, 6 deg., and 8th, 5 deg. F.

On the 9th of April, 1911, a snow storm, unprecendented in Halifax, fell upon the city. It began early in the forenoon and continued all day and the greater part of the night. The wind was northeasterly and the storm seems to have extended over the whole province. The depth of snow was 9.2 inches.

During January, 1911, there were six cold nights in succession, during which the thermometer registered a minimum temperature as follows:

16th	2.2	
17th	9.0	below zero
18th	10.8	" "
19th	4.8	" "
20th	3.6	
21st	1.3	

This record was unrivalled by the cold weather of February, 1911, when the temperature recorded during one week was:

12th	4.8	below zero
13th	0.2	" "
14th	2.0	" "
15th	2.2	" "
16th	0.8	
17th	8.4	

The record for January, 1912, was:

24th	4.6	
25th	2.2	below zero
26th	6.7	" "
27th	6.0	" "
28th	1.2	
29th	0.0	

From the diary of the late George Seymour Crichton, the following notes are copied:

February 7, 1855—"Thermometer 20 degrees below zero, the lowest I ever saw. At Citadel 25 deg. below zero."

    "   5, 1863—"Thermometer 14 deg. below zero."

    "   7, 1865—"Thermometer 10 deg. below zero at 8 a. m. Harbour frozen over. Hundreds crossing on the ice."

    "   8, 1865—"Crossed the harbour on the ice."

    " 11, 1865—"(Sunday) Hundreds crossing the harbour on the ice."

    " 12, 1865—"Steamer made passage through the ice from Dartmouth to Halifax."

    "   6, 1866—"Thermometer 13 deg. below zero."

    "   7, 1866—"Thermometer 12 deg. below zero."

    "   8, 1866—"Thermometer 14 deg. below zero."

Since the last meteorological notes were presented to the Institute, the highest and lowest monthly records have been altered as follows:

Month	Year	Maximum (Inches)	Former Year	Record (Inches)	Year	Minimum (Inches)	Former Year	Record (Inches)
April...	1906	8.381	1889	7.403	....	....	....	....
June....	....	....	....	....	1909	1 066	1879	1.191
August.	1908	10.658	1887	8.351	1906	1.509	1899	1 542

The following tables give records corrected to December
31st, 1911:

MAXIMUM, MINIMUM AND MEAN PRECIPITATION

Month	Year	Maximum (inches)	Minimum (inches)	Mean 1869–1911 (inches)
January	1895	10.131	....	5.766
"	1896	....	1.720	....
February	1870	9.780	....	5.829
"	1901	... .	0.966	....
March...........	1878	10.284	....	5.325
"	1889	....	2.046	....
April	1906	8.381	... .	4.312
"	1886	....	0.820	....
May	1886	8.819	....	4.087
"	1903	....	0.676	.. ..
June	1874	7.920	....	3.709
"	1909	....	1.066	....
July	1896	8.729	. ...	3.811
"	1894	....	1.059	....
August	1908	10.658	....	4.303
"	1906	....	1.509	... .
September	1896	12.092	....	3.824
"	1878	....	0.800	.. ..
October	1896	15.039	....	5.463
"	1897	... .	0.746	....
November	1898	10.248	....	5.741
"	1882	....	1.392	....
December	1893	10.167	....	5.304
"	1875	....	1.614	....
Totals 1896..	... .	69.862	....	56.523
" 1894..	....	.. ..	45.808	....

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING THE NUMBER OF TIMES THAT THE TOTAL PRECIPITATION, EACH DAY FROM 1894 TO 1911 INCLUSIVE, HAS BEEN NEAREST TO A SERIES OF AMOUNTS RANGING FROM ONE-HUNDREDTH OF AN INCH TO FIVE AND A HALF INCHES

YEAR	1/100	1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4½	5½	Total Rainfall for the Year	No. of Days Rain or Snow Fall
1894	50	42	13	16	9	7	5	5	5	6	2	2	2	2				1	1							45.808	166
1895	33	31	23	14	10	6	4	10	7	1	8	5	3	1		2	1						1	1		62.152	161
1896	45	30	19	12	10	8	5	7	6	3	2	3	6	1						1	1					69.862	183
1897	48	34	15	16	7	11	6	4	2	5	3	4	1			1										51.522	193
1898	46	34	20	17	14	9	6	6	6	4	3	8	2	1	1	1		1	1							60.480	196
1899	49	23	18	7	5	7	7	5	8	5	3	5	3	2	2	1		1	1							53.013	169
1900	38	47	18	13	12	6	12	4	2	6	5	5	2	2		1							1			59.697	198
1901	56	41	11	18	8	4	2	3	4	1	5	5	4	1	3	1										58.096	195
1902	46	44	17	20	15	5	3	7	5	3	4	3	2		3											51.916	188
1903	38	24	23	24	9	10	5	6	3	2	4	5	2	3	2		1									59.125	179
1904	37	36	20	18	10	8	6	6	4	3	4	2	2	1	1		1									57.194	196
1905	44	36	15	15	13	5	6	4	3	3	5	4	1	2		1	1		1							47.796	182
1906	40	25	16	10	9	10	8	2	3	3	6	6	3	4		1		2								64.139	194
1907	55	32	15	11	12	10	9	5	5	3	5	1	3	4		1										54.916	205
1908	40	32	17	13	10	3	4	3	5	3	5	8	1	3	1		2	1							1	64.870	160
1909	51	46	24	14	11		3	5	2	1	2	3	2	4		1	1									54.322	194
1910	52	29	18	19	12	7	3	10	4	2	4		3	3	1											67.381	200
1911	35	34	19	14	10	11	6	3	2	3	1		3	1		1			1							50.449	173
Totals	803	639	319	271	186	127	100	95	76	57	67	71	45	30	14	12	7	6	5	1	1		2	1	1	1032.737	
Means	44	35	18	15	10	7	6	5.3	4.2	3.2	3.7	4	2.5	1.7	0.8	0.7	0.4	0.3	0.3	0.1	0.1		0.1	0.1	0.1	57.374	185

PRECIPITATION AT HALIFAX, N. S.

Table showing the monthly and annual depth of rain and melted snow, expressed in inches ; also the amount that has fallen from January 1st to the end of each month, inclusive, during each year.

YEAR	January	February	January to Feb. inclusive	March	January to Mar. inclusive	April	January to April inclusive	May	January to May inclusive	June	January to June inclusive
1869..	4.530	4.380	8.910	7.950	16.860	2.570	19.430	5.570	25.000	3.920	28.290
1870..	6.670	9.780	16.450	3.080	19.530	3.860	23.390	3.190	26.578	1.690	28.270
1871..	3.730	5.880	9.610	6.160	15.770	4.880	20.650	2.590	23.240	2.960	26.200
1872..	3.880	4.490	8.370	5.370	13.740	2.850	16.590	4.440	21.030	4.230	25.260
1873..	7.830	1.610	9.440	4.090	13.530	2.860	16.390	2.340	18.730	2.960	21.690
1874..	5.420	5.310	10.730	3.980	14.710	4.550	19.260	4.770	24.030	7.920	31.950
1875..	3.481	5.877	9.378	2.113	11.491	3.378	14.869	3.977	18.846	6.067	22.913
1876..	3.451	6.456	9.907	6.334	16.241	3.125	19.366	4.664	24.030	3.384	27.414
1877..	4.200	1.809	6.009	8.666	14.675	3.801	18.476	4.024	22.500	3.841	26.341
1878..	7.522	2.697	10.219	10.284	20.503	3.502	24.005	5.759	29.764	4.477	34.241
1879..	4.400	3.001	7.401	6.202	13.603	3.481	17.084	4.687	21.771	1.191	22.962
1880..	7.733	5.122	12.855	3.365	16.220	4.797	21.717	4.088	25.105	1.343	26.448
1881..	3.607	5.329	8.936	6.556	15.492	3.398	18.990	2.460	21.450	5.308	26.751
1882..	6.840	5.949	12.789	7.068	19.857	4.824	24.681	4.677	29.358	5.507	34.865
1883..	4.930	3.860	8.790	4.941	13.731	3.703	17.434	8.613	26.047	3.322	29.369
1884..	4.406	6.161	10.567	7.034	17.601	7.213	24.814	3.629	28.443	3.773	32.216
1885..	6.388	5.090	11.478	3.889	15.367	3.520	18.887	3.282	22.169	2.749	24.918
1886..	8.670	3.842	12.512	4.027	16.539	0.823	17.362	8.819	26.181	2.708	28.889
1887..	7.706	6.735	14.441	4.449	18.890	6.396	25.286	2.126	27.412	2.121	29.533
1888..	5.442	6.284	11.726	4.310	16.036	3.675	19.711	2.877	22.588	4.939	27.527
1889..	4.391	6.181	10.572	2.046	12.618	7.403	20.021	3.871	23.892	3.755	27.647
1890..	3.963	4.645	8.608	9.889	18.497	2.958	21.455	3.970	25.425	3.440	28.865
1891..	8.383	8.740	17.123	2.685	19.808	4.010	23.818	4.195	28.013	4.131	32.144
1892..	6.321	2.605	8.926	5.986	14.912	2.653	17.565	5.459	23.024	3.638	26.662
1893..	4.781	5.979	10.760	2.303	13.063	4.209	17.272	5.054	22.326	1.753	24.079
1894..	7.122	3.571	10.693	3.623	14.316	5.648	19.964	1.769	21.733	3.803	25.536
1895..	10.131	4.605	14.736	5.931	20.667	3.956	24.623	4.089	28.712	1.827	30.539
1896..	1.720	4.199	5.919	8.786	14.705	1.413	16.118	2.532	18.650	4.671	23.321
1897..	5.896	2.898	8.794	5.470	14.264	6.211	20.475	4.613	25.088	6.070	31.158
1898..	4.060	4.422	8.482	4.068	12.550	7.346	19.896	2.366	22.262	5.598	27.860
1899..	5.083	3.613	8.696	7.178	15.874	3.278	19.152	3.677	22.829	3.875	26.704
1900..	8.532	5.277	13.809	6.577	20.386	3.949	24.335	4.254	28.589	2.656	31.245
1901..	6.043	0.966	7.009	4.102	11.111	6.318	17.429	5.556	22.985	6.959	29.944
1902..	3.289	2.735	6.024	7.757	13.781	3.067	16.848	3.725	20.573	4.908	25.481
1903..	5.082	3.712	8.794	7.294	16.088	5.515	21.603	0.676	22.279	3.493	25.772
1904..	6.318	5.328	11.646	5.590	17.236	5.912	23.148	3.315	26.463	2.668	29.131
1905..	8 290	5.326	13.616	2.804	16.420	1.260	17.680	3.217	20.897	4.970	25.867
1906..	4.624	5.208	9.832	7.142	16.974	8.381	25.355	6.208	31.563	1.704	33.267
1907..	6.186	4.481	10.667	3.364	14.031	3.218	17.249	3.344	20.503	3.723	24.316
1908..	6.172	6.112	12.284	3.129	15.413	6.373	21.786	6.248	28.034	4.320	32.354
1909..	5.174	4.815	9.989	5.056	15.045	3.987	19.032	6.329	25.361	1 066	26.427
1910..	9.147	6.966	......	4.250	......	8.202	......	3.312	......	5.091	.....
1911..	6.406	4.798	......	4.086	.. ....	2.898	......	1.392	......	2.942	.....
Totals	247.950	250.636	......	228.984	. .....	185 401	......	175.753	......	159.471	.....
Means for 43 years	5.766	5.829	......	5.325	.. ....	4.312	......	4.087	......	3.709	.....

PRECIPITATION AT HALIFAX, N. S.

Table showing the monthly and annual depth of rain and melted snow, expressed in inches ; also the amount that has fallen from January 1st to the end of each month, inclusive, during each year.

YEAR	July	January to July inclusive	August	January to Aug. inclusive	September	January to Sept. inclusive	October	January to Oct, inclusive	November	January to Nov. inclusive	December	Total for the Year
1869....	2.920	31.840	2.580	34.420	1.570	35.990	7.300	43.290	5.470	48.760	5.770	54.530
1870....	3.210	31.480	2.200	33.680	3.330	37.010	6.830	43.840	6.440	50.280	5.880	56.160
1871....	3.380	29.580	3.690	33.270	4.810	38.080	4.490	42.570	4.180	46.750	4.390	51.140
1872....	2.880	28.140	6.820	34.960	1.410	36.370	4.880	41.250	6.650	47.900	6.160	54.060
1873....	3.900	25.590	4.450	30.040	4.480	34.520	8.630	43.150	7.980	51.130	4.310	55.440
1874....	2.290	34.240	3.370	37.610	5.040	42.650	2.460	45.110	3.580	48.690	5.490	54.180
1875....	5.612	28.525	3.555	32.080	2.060	34.140	9.976	44.116	5.544	49.660	1.614	51.274
1876....	3.914	31.328	1.909	33.237	6.094	39.331	4.068	43.397	7.397	50.796	3.176	53.972
1877....	4.468	30.809	3.539	34.348	3.164	37.512	6.857	44.369	8.678	53.047	4.493	57.540
1878 ..	1.483	35.724	3.127	38.851	0.800	39.651	5.061	44.712	6.989	51.621	5.119	56.740
1879....	3.843	26.805	4.827	31.632	2.596	34.223	4.755	38.983	4.823	43.806	4.029	47.835
1880....	3.086	29.534	3.920	33.454	5.712	39.166	4.590	43.756	4.704	48.460	4.393	52.853
1881 ...	3.177	29.935	3.062	32.990	3.105	36.095	4.206	40.301	4.420	44.721	7.034	51.755
1882....	5.071	39.936	3.925	43 861	5.914	29.775	7.403	57.178	1.392	58.570	3.452	62.022
1883....	3.540	32.909	5.342	38.251	3.864	42.115	5.841	44.956	3.478	51.434	6.678	58.112
1884....	8.294	40.510	2.771	43.281	1.788	45.069	3.093	48.162	5.992	54.154	9.124	63.078
1885....	5.817	30.735	3.001	33.736	2.497	36.233	6.280	42.513	5.423	47.936	8.693	50.629
1886....	6.525	35.414	4.526	39.940	4.459	44.399	2.136	46.534	5.284	51.818	5.469	57.287
1887....	2.045	31.578	8.351	39.929	3.308	43.237	3.058	46.295	6.718	53.013	4.120	57.133
1888 ...	5.001	32.528	7.000	39.528	5.331	44.859	6.359	51.718	6.802	58.520	7.774	66.294
1889....	2.668	30.310	2.633	32.948	1.399	34.347	4.179	38.526	7.145	45.671	2.988	48.059
1890....	2.141	31.006	7.042	38.048	4.534	42.582	6.603	49.185	3.716	52.901	7.202	60.103
1891....	4.003	36.147	3.385	39.532	3.052	42.584	9.621	52.205	2.388	54.593	4.076	58.669
1892....	2.710	29.372	6.809	36.181	1.744	37.925	3.472	41.397	9.240	50.637	3 053	53.690
1893....	4.757	28.836	5.954	34.790	4.391	39.181	5.640	44.821	3.760	48.581	10.167	58.748
1894....	1.059	26.595	3.993	30.588	1.010	31.589	3.863	35.461	5.785	41.246	4.562	45.808
1895...	3.924	34.463	5.502	39.965	2.491	42.456	5.627	48.083	8.223	56.306	5.846	62.152
1896....	8.729	32.050	3.037	35.087	12.092	47.179	15.039	62.218	4.396	66.614	3.248	69.862
1897....	3.661	34.819	5.185	40.004	1.169	41.173	0.346	41.919	6.051	47.970	3.552	51.522
1898....	3.652	31.512	5.651	37.163	4.153	41.321	4.845	40.166	10.248	56.414	4.066	60.480
1899....	5.747	32.451	1.542	33.993	3 201	37.194	6.191	42.385	4.590	47.975	5.038	53.013
1900....	1.872	33.117	3.993	37.110	5.043	42.153	7.365	49.518	6.858	56.376	3.321	59.697
1901....	1.585	31.529	3.656	35.185	6.872	42.057	4.906	46.963	2.560	49.523	8.573	58.090
1902....	1.651	27.132	4.767	31.899	4.657	36.556	4.252	40.808	3.813	44.621	7.295	51.916
1903....	4.313	30.085	4.247	34.332	4.237	38.569	6.368	44.937	9.598	54.535	4.590	59.125
1904...	2.323	31.454	6.511	37.965	4.502	42.467	5.031	47.498	5.107	52.605	4.589	57.194
1905 ...	1.927	27.794	2.733	30.527	2.753	33.280	1.539	34.819	6.348	41.167	6.268	47.435
1906 ...	6.125	39.392	1.509	40.901	3.374	44.275	3.986	48.261	5.920	54.181	9.958	44.139
1907....	3.381	27.697	4.865	32.562	4.260	36.822	5.340	42.162	6.039	48.201	6.715	54.916
1908....	5.700	38.054	10.658	48.712	1.413	50.125	3.704	53.829	3.272	53.101	7.769	64.870
1909....	3.644	30.071	3.388	33.459	5.938	39.397	7.165	46.562	4.998	51 560	2.762	54.322
1910....	5.366	......	2.686	......	3.947	......	8.622	......	5.202	.....	4.590	67.381
1911....	2.493	......	3.336	.....	6.854	......	2.024	......	9.822	.....	3.398	50.449
Totals.	163.887	......	185.047	......	164.423	.....	234.900	.... ..	246 843	......	228.064	2430.482
Means for 43 Years	3.811	......	4.303	.....	3.824	......	5.463	......	5.741	......	5.304	56.523
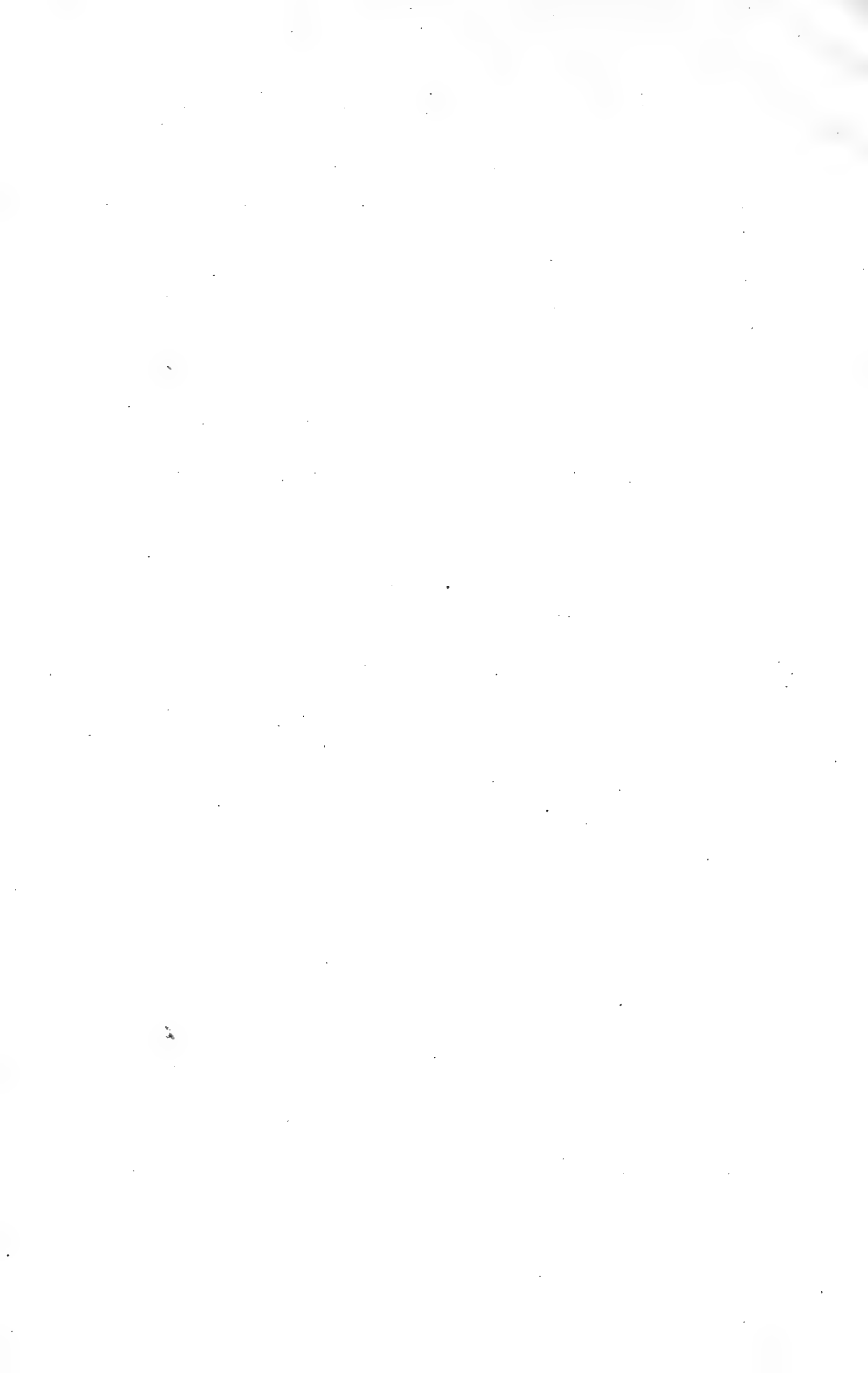
TRANSACTIONS

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SESSION OF 1911-1912

On the Behaviour of Iron Salts, in the Presence of Albumens and Other Organic Substances, Towards Certain Reagents.—By Henry Jermain Maude Creighton, M. A., M. Sc., Dr. Sc., *Lecturer on Physical Chemistry,* Dalhousie University, Halifax, N. S.*

I. Introduction.

In the course of another investigation, it was observed by the writer that, under certain conditions, solutions of soluble Prussian blue were decolorized by white of egg. As the writer was unable to obtain any satisfactory information regarding this behaviour, the present investigation was carried out with a view of throwing new light on the associations of iron with native and derived proteins.

The prevention of many reactions by the presence of certain organic substances is well known. For example, the precipitation of ferric and aluminium hydroxides is prevented by the presence of small quantities of non-volatile organic acids, notably tartaric acid[1], of sugar, of glycerine, and of other organic substances. The cause of this is to be found in the formation

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* Contributions from the Science Laboratories of Dalhousie University — [Chemistry].

1. Staedeler and Krause : Jahresb., 746, (1854).

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of a soluble complex ion brought about by the entrance of the metal into the hydroxyl group of these substances.

It has long been known that albumen manifests a marked tendency to hinder many chemical reactions. The cause of this may be either physical or chemical. *von Meyer* and *Lottermoser*[1] have shown, for instance, that small quantities of egg albumen prevent the precipitation of silver hydrosol by salts. The effect of albumen on the ionization of silver nitrate has been investigated by *Galeotti*[2] who found, that small quantities greatly diminish the concentration of the silver ions. It is possible that albumen may, in some cases, diminish the ionization of a substance to such an extent as to prevent its recognition by the usual tests. Albumen readily forms complexes with salts of both the alkali and the heavy metals, as well as with many bases and all the mineral acids except ortho- and pyro-phosphoric acid. These albumen compounds may be divided into two classes: those in the which the metal is present as a simple cation; and those in which it forms part of a complex anion, and in which, for this reason, its presence cannot be demonstrated by ordinary reagents. Complexes formed by albumen with HCl, HNO_3, H_2SO_4, $NaOH$, KOH, $NaCl$, KCl, $MgCl_2$, $CaCl_2$, $(NH_4)_2SO_4$, $MgSO_4$, Na_2SO_4, and K_2SO_4 have recently been studied by *Mayer*[3]. The existence of the complex can often be readily shown. For example, when hydrochloric acid is added to a solution of white of egg and the mixture filtered so as to remove the precipitate which forms, it is found that no silved chloride is thrown down on the addition of silver nitrate to the filtrate. With salts of most of the heavy metals albumen forms compounds of the type[4]

$$MO.\ C_{12}H_{112}N_{18}SO_{22};$$

but with iron salts the compound is more complex[5]. These

1. von Meyer, E., and A. Lottermoser : J. pr. Chem., **56**, (2) 214, (1897).
2. Galeotti, G. : Zeitschr. physiol. Chem. **42**, 330, (1904).
3. Mayer, A. : Compt. rend., **143**, 515, (1906).
4. Piotrowski : Jahsesber. über die Fortschritt der Chemie, 534, (1857).
5. Brücker : Zeitschr. für Chemie, 61 (1871).

compounds are unstable and the albumen may be recovered by treatment with acids, when it is precipitated and the metal goes into solution.

Physiologists have long divided iron compounds into two classes; those which contain "organic" iron, and those which contain "inorganic" iron. Macallum[1] has shown that haematoyxlin may be used to distinguish between these two classes of compounds; and in the experiments which follow I have employed this reagent to demonstrate the condition of the iron.

The terms "bound" and "unbound", as used by Prof. Fraser Harris are, I think, to be preferred to the more ambiguous "organic" and "inorganic". As even better than "bound" and "unbound", however, I would suggest the use of the terms *"non-ionic"* and *"ionic"*; for inorganic or unbound denotes the simple ionic state, while organic or bound denotes a condition which is not elementary, but often quite complex. A compound containing "ionic" iron would be one in which the iron exists as a cation; and in a compound containing "non-ionic" iron the iron would not be present as a simple ion, but would exist as *part* of a complex ion, usually as part of the anion. This classification is justified by experiment, for compounds such as ferric chloride, ferrous sulphate, ferric acetate, and potassium ferri-ferrocyanide (soluble Prussian blue), all of which contain a simple iron cation, give a deep blue black or violet black colouration with haematoxylin; while, on the other hand, compounds such as potassium ferricyanide or potassium ferrocyanide, in which the iron is not present as a simple ion, but as part of a complex anion, give no reaction with haematoxylin.

II. EXPERIMENTAL.

Albumen: A 15% white of egg solution, a 10% solution of Merck's "Egg Albumen granular", and a 10% solution of Merck's "Serum Albumen" were used in the following experiments. The egg and serum albumen were dissolved in very

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1. **Macallum, A. B. :** J. Physiol, **22**, 92, (1897-1898).

dilute sodium chloride solution.   These solutions were filtered before using.

Haematoxylin: A 0.5% solution of haematoxylin was used in the following experiments.

(a)   *Experiments with ferric chloride.*

To 10 c. c. of 1.0% ferric chloride solution 10 c. c. of the white of egg solution were added and the mixture divided into two parts.   One portion was allowed to stand at room temperature for a few minutes, and the other kept at 60° for the same length of time.   The two portions were divided into several parts and treated with different reagents.   The following results were obtained:

With NaOH no precipitate formed.
    "   NH$_4$OH no precipitate formed.
    "   K$_3$Fe(CN)$_6$ no change.
    "   K$_3$Fe(CN)$_6$ slight blue precipitate formed.
    "   KCNS deep red colouration.
    "   (NH$_4$)$_2$S black precipitate formed.
    "   Haematoxylin violet black colouration appeared.

Similar results were obtained when 10 c. c. of either the serum albumen or the egg albumen solutions were employed instead of the white of egg solution.   It was found with these substances that some of the reagents caused albumen to separate from the solution.   Control experiments, in which the albumen solution was replaced by an equal volume of distilled water, were carried out.   In these it was found that sodium hydroxide, ammonium hydroxide, potassium ferricyanide, and potassium ferrocyanide all threw down the usual precipitates.

On addition of the albumen solutions to the ferric chloride, it was observed that the brownish colour of the mixtures gradually deepened on standing, thus suggesting that albumen increased the degree of hydroysis of the iron salt.   This result was also observed when a mixture of white of egg and ferric

chloride was warmed. To 5 c. c. of 1.0% ferric chloride solution 5 c. c. of the white of egg were added in one case, and in another the chloride was diluted with 5 c. c. of distilled water. These solutions were kept at 65° for ten minutes. At the end of this time the solution containing the albumen was found to be of a deeper colour than the other. To determine whether the non-formation of a precipitate of ferric hydroxide or of Turnbull's blue, in the foregoing experiments, was due to the conversion of the iron into colloidal ferric hydroxide by hydrolysis, sodium acetate was added drop by drop to a solution of ferric chloride, until its colour was somewhat deeper than that of the mixture of white of egg and ferric chloride that had been warmed; on adding ammonia to the acetate solution a heavy precipitate of ferric hydroxide was thrown down, thus proving that only a small quantity of the iron in the egg solution was in the form of colloidal hydroxide.

Hydrochloric acid was found to produce a precipitate when added to a solution of ferric chloride and albumen. To a mixture of 5 c. c. of 1% ferric chloride and 10 c. c. of the white of egg solution a few drops of dilute hydrochloric acid were added. At the end of some minutes no precipitate was observed to have formed. With several c. c. of the acid, however, a precipitate was slowly thrown down. The precipitate was filtered off, and to different portions of the light yellow filtrate ammonia, haematoxylin, potassium ferrocyanide, and potassium sulphocyanide were added. In each case the usual reaction for ferric iron took place. Further addition of hydrochloric acid precipitated no more alubumen from the filtrate. On boiling some of the filtrate, albumen coagulated and was thrown out of solution. This was filtered off and potassium ferrocyanide added to the almost colourless filtrate. The dark blue precipitate was removed by filtration. On boiling the colourless filtrate a light blue flocculent precipitate separated from the solution. The results obtained in this experiment point to the existence of a complex of the iron salt with the albumen. This complex is

stable towards heat.   When potassium ferrocyanide is present, however, the complex is precipitated by boiling the solution.

A mixture consisting of equal parts of the white of egg and 1.0% ferric chloride solution, was found to be more stable towards heat than a pure albumen solution of the same concentration; whereas the mixture did not commence to coagulate until the temperature was raised to 65°, the pure albumen solution became cloudy at 61.5°.

(b)   *Experiments with potassium ferricyanide.*

White of egg solution, egg albumen, and serum albumen were all found to prevent the precipitation of potassium ferricyanide, in dilute solution, by ferrous salts.   On the addition of a few drops of ammonium ferrous sulphate to a mixture consisting of 2 c. c. of 0.1% potassium ferricyanide and 5 c. c. of the white of egg solution only a very faint blue colouration was produced.   When the concentration of the potassium ferricyanide was smaller than this, a blue colouration did not occur on the addition of the ammonium ferrous sulphate.   5.0 c. c. of 0.1% potassium ferricyanide were mixed with 25 c. c. of the white of egg solution.   Ammonium ferrous sulphate solution was then added drop by drop to the pale yellow mixture until it became colourless.   This disappearance of the yellow colour points to the occurrence of chemical change on the addition of the ammonium ferrous sulphate, and is probably due to the disappearance of the ion to which the colour of the solution is due.   A blue black colouration appeared when a few drops of haematoxylin were added to part of the decolourised solution. The decolourised solution turned blue on the addition of a drop of dilute hydrochloric acid.   Excess of hydrochloric acid caused a blue precipitate to separate slowly from the solution.

With solutions containing no albumen and the above concentrations of potassium ferricyanide, ammonium ferrous sulphate gave deep blue precipitates.

To a mixture of 5 c. c. of 0.1% potassium ferricyanide and 25 c. c of the white of egg solution, sufficient dilute hydro-

chloric acid was added to throw down a white precipitate. The precipitate was filtered off and small portions of the filtrate were tested with ammonium ferrous sulphate, and haematoxylin. The former gave a deep blue precipitate, but no reaction occurred with the latter reagent. To the remainder of the filtrate more hydrochloric acid was added, but no further precipitation took place; on boiling, however, a white precipitate separated from the solution. It was found that the light yellow filtrate from this precipitate could be boiled without further precipitation taking place. To the cooled filtrate a few drops of ammonium ferrous sulphate were then added. The solution turned blue, and on standing a deep blue precipitate separated out; on boiling the solution the precipitate became flocculent, resembling a precipitate of aluminium hydroxide. The precipitate when heated on a platinum foil charred at a low temperature. This precipitate could not have consisted of simply Turnbull's blue; for when ammonium ferrous sulphate was added to a hydrochloric acid solution of potassium ferricyanide having the same degree of yellow colour as the above filtrate, and the mixture boiled, the precipitate which separated out was not flocculent, but finely divided. Moreover, on allowing it to settle and pouring off the supernatant liquid the blue precipitate was found to dissolve in water. The results of this experiment suggest the formation of a complex by the iron salt and albumen, which is stable towards heat, and which is precipitated by ammonium ferrous sulphate.

Like ferric chloride, potassium ferricyanide increases the coagulation temperature of albumen. A solution of potassium ferricyanide and white of egg, of one half the concentration previously employed, first became turbid at $64.5°$; while a pure white of egg solution, of the same concentration, became cloudy at $61.5°$. When, besides the potassium ferricyanide and white of egg, a very small quantity of ammonium ferrous sulphate was present in the solution, coagulation did not take place below $75°$.

(c)   *Experiments with potassium ferric-ferrocyanide (soluble Prussian blue).*

It has already been mentioned in the introduction that, under certain conditions, white of egg solution is capable of decolourizing a solution of soluble Prussian blue. Neither the egg albumen nor the serum albumen were found to decolourize soluble Prussian blue as readily as the white of egg solution.

10 c. c. of 0.05% soluble Prussian blue were mixed with 10 c. c. of the white of egg solution and the mixture kept at 60° for an hour. At the end of this time the deep blue solution had become practically colourless. The fading of the blue colour took place gradually. With pure white of egg, or at a higher temperature, the decolourization of the soluble Prussian blue was found to proceed with greater rapidity. When a mixture of equal volumes of 0.05% soluble Prussian blue and the white of egg solution were kept at room temperature, no apparent change in the intensity of the blue colour of the solution was observed at the end of six hours. To some of the decolourized solution haematoxylin was added; *no precipitation occurred,* thus proving that the Fe^{III} ion of soluble Prussian blue was no longer present as such. The addition of dilute hydrochloric acid or concentrated salt solutions to some of the decolourized solution caused the precipitation of a white substance, which gradually turned to a deep green blue colour on standing or on treatment with hydrogen peroxide. No change was observed on the addition of hydrogen peroxide to some of the decolourized soluble Prussian blue mixture.

Like the foregoing mixtures of iron salts with albumen, a solution of 0.05% soluble Prussian blue and an equal volume of the white of egg, which had been decolourized by heating at 60°-70°, was stable to heat and could be boiled without the albumen coagulating. Indeed, it was found that the substances could be rapidly brought to boiling immediately after mixing without precipitation taking place. At this temperature the mixture became colourless in two or three minutes.

(d) *Experiments with gelatine.*

On account of the close relationship between the albumens and the albuminoids, the following experiments were carried out to determine the influence of the presence of the latter substances on reactions of certain iron salts. As a typical albuminoid gelatine was employed. A 10% solution was found to be quite fluid at 20°.

No precipitation of ferric hydroxide occurred on the addition of ammonia to a mixture consisting of equal volumes of 1.0% ferric chloride, 6% gelatine solution, and distilled water; haematoxylin, however, gave a violet black colouration. In a control experiment ferric hydroxide was precipitated by ammonia.

1 c. c. of 0.1% potassium ferricyanide and 5 c. c. of 6% gelatine solution were added to 5 c. c. of distilled water. Although the mixture turned blue on the addition of ammonium ferrous sulphate, no precipitate formed. The blue colour disappeared from this solution on boiling. With 8 c. c. of 10% gelatine solution no blue colouration appeared on the addition of ammonium ferrous sulphate to the mixture; if however, besides the ammonium ferrous sulphate, a few drops of hydrochloric acid were added, the solution turned blue and a precipitate of Turnbull's blue slowly formed. In the control experiments, in which the gelatine solution was replaced by an equal volume of distilled water, a deep blue precipitate was obtained on the addition of the ammonium ferrous sulphate.

It was found that a mixture containing 5 c. c. of 0.05% soluble Prussian blue and 5 c. c. 6% gelatine could be kept at 95°-100° for one and a half hours without the blue colour of the solution appreciably decreasing in intensity. With 7 c. c. of 10% gelatine, however, the colour of the Prussian blue faded completely under these conditions. The blue colour of the mixture returned on the addition of a few drops of either dilute hydrochloric acid or hydrogen peroxide. With hydrochloric

acid the blue colour was deeper than with hydrogen peroxide. When a decolourized solution was allowed to stand for twenty-four hours, the jelly, which formed*on cooling, was found to be deep blue at the surface. The blue colour gradually decreased until, at a depth of three inches, the jelly was colourless.

(e)   *Experiments with ferrous salts.*

Dilute solutions of ammonium ferrous sulphate and potassium ferrocyanide were separately mixed with varying quantities of the white of egg solution, and allowed to stand some minutes. On adding ammonia or sodium hydroxide to the ferrous ammonium sulphate mixtures ferrous hydroxide was invariably precipitated. When the concentration of the white of egg was relatively large, the ferrous hydroxide precipitated somewhat slowly. The potassium ferrocyanide mixtures were tested with solutions of iron alum and copper sulphate. On the addition of a few drops of the alum solution to the mixture a deep blue precipitate was always produced, while with the copper sulphate solution a brick red precipitate of copper ferrocyanide was immediately formed. The same results were obtained when gelatine was used instead of white of egg.

(f)   *Experiments with other organic substances.*

Dilute solutions of all the iron salt previously used were separately mixed with varying quantities of cane sugar, of tartaric acid, and of glycerine. The mixtures containing soluble Prussian blue were kept at 60° for an hour, while the others were allowed to stand at room temperature for some minutes. Apart from the prevention of the precipitation of ferric hydroxide on the addition of ammonia or sodium hydroxide to the mixtures containing ferric chloride, it was found that neither sugar, tartaric acid, nor glycerine apparently hindered the different iron salts from reacting with the various reagents previously used for their denomstration.

III.   DISCUSSION OF RESULTS.

From the experiments described, it will be seen that albumens, as well as the closely related albuminoid gelatine, tend to prevent certain reactions of ferric chloride, potassium ferricyanide, and soluble Prussian blue; while on the other hand, the presence of albumen or gelatine does not appear to hinder reactions with ferrous ammonium sulphate or potassium ferrocyanide.   The prevention of reactions of iron salts by albumen or derived proteins, such as gelatine, seems to be closely associated with the state of oxidation of the iron; for ferric chloride, potassium ferricyanide

$$\left(C_3N_3\right) \underset{}{\overset{\displaystyle \diagup \quad K}{\diagdown}} \quad \overset{\text{III}}{\underset{\diagup \quad K}{\text{Fe}}} \quad,$$

and soluble Prussian blue

$$\left(C_3N_3\right) \quad \overset{K}{\underset{H}{\diagup}} \quad \overset{\text{II}}{\text{Fe}} \quad,$$

$$\left(C_3N_3\right) \quad \overset{H}{\diagdown} \quad \overset{\text{III}}{\text{Fe}} \overset{\diagup OH}{\underset{\diagdown OH}{}}$$
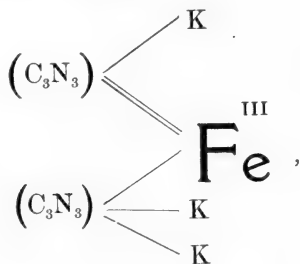
each contain at atom of trivalent iron.   In potassium ferricyanide the trivalent iron forms part of the anion $Fe\,(CN)_6{}^{\text{III}}$.

As to just how reactions of compounds containing trivalent iron are hindered or prevented by the presence of native or derived proteins, three possibilities present themselves: either the protein may decrease the dissociation of the iron compound to such an extent that ionic reactions are no longer possible; or it may exert a so called "protective action" on the iron salt, similar to that of gelatine on colloidal gold, which is due to the gelatine forming a very thin coating over each of the gold particles[1]; or, lastly, the protein may be *intimately associated* with the iron salt. Intimate association of the protein and the iron salt may be brought about through the formation of a *chemical compound,* or by *adsorption,* giving rise to what may be looked upon as a *physical* compound.

If the phenomenon were to be ascribed to either decrease in dissociation or to protective action, we should expect proteins to hinder reactions of salts containing bivalent iron as well as those of salts containing trivalent iron. On the other hand the *specificity* of the proteins employed, points to their *intimate association* with trivalent iron.

It is well known that many colloids have a tendency to adsorb certain substances, which are in true solution, with the formation of so called adsorption compounds. Since such compounds do not possess a constant composition they cannot be looked upon as chemical. The formation of such compounds depends on several factors of which the following are the more important: the nature and structure of the colloid, the nature of the solvent, the nature of the dissolved substance, the condition of the molecule of the dissolved substance, and lastly, the temperature.

In the foregoing experiments the nature and structure of the colloidal albumen and gelatine are not very dissimilar, while those of the ferric and ferrous salts employed are greatly so. In view of what has been said we should expect to find

1. Mines, G. R. : Proc. Physiol. Soc., November 18th, 1911.

ferrous, as well as ferric salts, adsorbed by albumen and gelatine. That this is not the case at once suggests that the selective adsorption of trivalent iron may be due to some electrical effect. In support of this it may be mentioned it has recently[1] been pointed out, that while the adsorption of non-electrolytes is probably due to surface tension phenomena, that of electrolytes is probably of electrical origin.

Additional evidence of the adsorption of ferric compounds by native and derived proteins is afforded by the fact that the coagulation temperature of albumen is increased by these sub-stances. This behaviour is in accordance with that observed by *Pauli* and *Handovsky*[2], who found that small concentrations of alkali salts retarded the coagulation of albumen, i. e. raised the coagulation temperature.

The supposition of the formation of a chemical compound is supported by the raising of the coagulation temperature of albumen when trivalent iron is present; by the disappearance of the colour of soluble Prussian blue on the addition of albumen or gelatine to its solution; and by the fact that the rate of fading of the blue colour increases as the temperature of the solution is raised. This last is a further argument against the hindering of the reactions being brought about by the protein lessening the degree of dissociation of the iron com-pounds. The fact that hydrochloric acid when added to mix-tures of potassium ferricyanide and albumen or gelatine, such as used in the foregoing experiments, liberates the ferricyanide so that it is demonstrable by ammonium ferrous sulphate and, in the case of albumen mixtures, also precipitates the albumen; the return of the blue colour to solutions of soluble Prussian blue that have been decolorized with gelatine, on the addition of hydrochloric acid, hydrogen peroxide, or on exposure to

1. Lachs, H. and L. Michaelis : Zeitschr. Elektrochem., **17**, 1, (1911) ; ibid. **17**, 917, (1911).

2 Pauli, W. and H. Handovsky : Beitrage z. chem. Physiol. u. Pathol., **11**, 415, (1908).

the air for some time; the white or pale blue precipitates thrown down by hydrochloric acid from solutions of soluble Prussian blue decolorized by albumen; and the fact that this latter precipitate turns to a deeper blue on treatment with hydrogen peroxide or on exposure to the air, constitute additional evidence of the existence of a chemical complex. The return of the blue colour to colourless solutions of soluble Prussian blue and gelatine, and to the substance precipitated by hydrochloric acid from colourless solutions of soluble Prussian blue and abumen, indicates that in the soluble Prussian blue protein complex the trivalent iron of the soluble Prussian blue has undergone reduction and is present in the bivalent condition.

The results obtained in this investigation indicate that native and derived proteins prevent the ordinary reactions of substances containing trivalent iron, owing to the formation of associations between the protein and the iron salt. There is reason to believe that this phenomenon is partly physical and partly chemical: physical in that the colloid attracts the iron salts and forms adsorption compounds; and chemical in that the proteid actually combines with the iron salt. These physical and chemical complexes are readily broken down by hydrochloric acid. Complexes of soluble Prussian blue with gelatine are also decomposed in solution by hydrogen peroxide, but those with albumen are not. One the other hand, these complexes seem fairly stable towards heat, and in the case of those formed with soluble Prussian blue a temperature of 100° does not effect decomposition. Through the formation of complexes of proteins with soluble Prussian blue, the trivalent iron of the latter is probably reduced to the bivalent condition. No indication that complexes are formed by proteins and salts containing bivalent iron has been obtained. Neither cane sugar, glycerine, nor tartaric acid appear to form chemical or adsorption compounds with either ferro- or ferri-salts.

It is the intention of the writer to extend these experiments.

In conclusion it may be pointed out that the results of this paper are not without physiological significance, for the ready formation of chemical or physical complexes between native and derived proteins and compounds containing trivalent iron, either as cation or as part of the anion, may possibly throw new light on the metabolism of iron[1].

Department of Chemistry, Dalhousie University.
Halifax, Nova Scotia,
March 2nd, 1912.

1. See the following paper in this Journal, by Professor Fraser Harris.

On the Intimate Associations of Inorganic Ions with Native and Derived Proteins.—By David Fraser Harris, M. D., D. Sc., F. R. S. E., *Professor of Physiology and Histology,* Dalhousie University, Halifax.*

We must assume that unless united to the living molecules (biogens) no food would be assimilated, no drug benefit us, and no poison harm us. We must have some sort of union, incorporation or molecular linking, and that cannot be outside the sphere of atomic affinities. Protoplasm must be chemically viewed as an unstable, molecular, protein complex to which, probably as side-chains, adhere carbohydrate molecules and fat molecules and many inorganic ions both anions and cations. The unmasking of this fat is called in pathology "fatty degeneration," the unloosening of this sugar is called tissue-diabetes. We have fat necrosis after certain poisonings; for instance, phosphorus and alcohol can unmask fat in many tissues of a persons the very opposite of obese, while after chloroform or an excessive percentage of carbon dioxide in the blood we have glycohaemia and the consequent glycosuria which means that the poison has displaced the sugar and sent it into the bloodstream. But further, a salt-free (ash-free) protoplasm, that is, salt-free living protein is only a conception of the chemists; protein is ash-free only in the laboratory. No doubt these ionic side-chains constitute mere traces, but as inorganic substances they play an exceedingly important part in the activities and existence of living matter. A salt-free diet will not support life. Dogs fed on ash-free fats, carbohydrates and proteins were moribund in twenty-six to thirty-six days.

But, further, the salts of the diet must be present in it in their natural unions and not merely in a solution added to the organic food. Whereas mice throve on a diet of dried cow's milk, they were moribund in twenty to thirty days on the sugar, fat and casein of milk to which a solution of the extracted salts of milk had been added. We know that a diminution in the amount of potassium absorbed will lead to scurvy.

It used to be said that as the salts contribute no energy, they are not incorporated into the living matter; this is quite a mistake, for although they do not yield energy, they are incorporated as truly as is the fat or carbohydrate or oxygen. It would appear that all the following must be present in the tissues and fluids, not necessarly all in all: sodium, potassium, calcium, magnesium, iron, phosphorus, chlorine, iodine, fluorine and arsenic. Without these, the living matter is not functionally intact: there is a metabolism of the inorganic as truly as there is of the organic.

Take the case of the beating heart; if perfused with distilled water, even containing oxygen and dextrose, it will shortly stop beating, and a loss of salts from it can be proved to have occurred. Now give it a perfusion-fluid with sodium chloride whose osmotic pressure is equal to that of the sodium chloride in the heart, and still it stops. This is found to be because we have left out the potassium and the calcium; the addition of these, the potassium chloride as dilute as 1 in 10,000 is enough, will cause the heart to beat rhythmically. Apparently the cardiac myoplasm establishes an equilibrium between certain organic ions within itself and others in the lymph of its spaces, the point of equilibrium being dependent upon the osmotic pressure of these substances in the surrounding fluids and on the affinities of the protoplasm for these substances. If any one ion predominates somewhat over the others, that is, is present in higher concentration than exists in normal lymph, effects which have been called "toxic" will supervene; thus if potassium is too abundant we have the heart stopping in potassium diastole,

if calcium be too abundant we have the heart stopping in the systole of calcium rigor.

Now the affinities of certain kinds of protoplasm for certain ions are quite different from those of other kinds of protoplasm for them. Thus the red corpuscles fix potassium and iron, the brain, phosphorus; the muscles, potassium; the bones and teeth, calcium and fluorine; the thyroid gland, iodine; and the fluids of the body chiefly sodium. The thyroid gland can, moreover, fix more iodine per unit of tissue than can any other tissue. Chemically speaking, therefore, protoplasm in different situations is chemically different; the protoplasm of the brain has not the same atomic affinities as that of muscle or bone or thyroid gland. The tissues are, however, supplied by lymph of practically uniform composition, so that these chemical differences have been said to be due to "selective affinity." Now these differences must be very slight. Dr. Jermain Creighton[1] has shown that egg-albumin, a native protein and a very direct product of living matter, can distinguish in its selective affinity between iron in the trivalent and iron in the divalent state. Dr. Creighton has found that egg-albumin apparently forms a union with the ferri-ion whether that be as in ferric chloride or in soluble Prussian Blue, (pottassium ferri-ferro-cyanide), both of which have trivalent iron as a cation; or in potassium ferricyanide in which trivalent iron is part of a complex anion. Some late work has shown the iron in haemoglobin to be the ferri-ion: so that it would appear that the point is not whether iron is cation or anion but whether it is tri- or di-valent. The difference is physico-chemically very slight, and yet the albumin takes cognizance of it. In accordance with these views some pharmacologists assert that simple anaemia is cured only by ferric salts. Dr. Creighton has further shown that even gelatine exhibits analogous selective affinities. Here, I think, we are in presence of some very important facts as indicating

the delicate nature of these unions of colloids with metallic ions, unions, which in some cases have been labelled "adsorptions." Now if this sort of thing can go on in non-living albumin what may not be chemically possible in the living bioplasm itself? Dr. Creighton speaks guardedly of "a complex" between the protein and the iron; but we may at least hold a salt-like union is effected and that the tri-valent iron is chemically bound. In accordance with this we have to remember Professor Macallum's test[1] for inorganic versus bound iron: a dilute (0.5%) solution of pure haemotoxylin gives with inorganic iron a blue black coloration, but with bound iron no reaction. Under the latter heading come haemogobin and both the potassium ferricyanide and the potassium ferrocyanide. In these the iron atom is bound in some fashion so as not to affect the haemotoxylin in the manner in which it can do when in the unbound condition of inorganic salts presumably ionised.

It used to be said that inorganic salts given as drugs have a tendency to be deposited in the liver; in more modern terminology it would be said that the hepatic protein has the power of binding the inorganic ions—mercury, arsenic, manganese, etc.—and therefore retaining them in the liver and so preventing them reaching the circulation in anything like the concentration in which they were absorbed. This capacity of the liver is but one expression of its *de*toxicating power in virtue of which it fixes many poisons, pathogenic toxins and others, and so prevents their entrance into the circulating blood.

There must therefore be constant interchanges between the living matter and the inorganic constituents of the lymph, for inorganic salts are being constantly absorbed and constantly excreted and so, on the whole, the per-centage of inorganic constituents in the tissues does not vary. Now the amount of any one constituent—iron, calcium, sodium,

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1. Macallum. A. B: J. Physiol., 22, 92, (1897-1898).

potassium, etc.—depends on its ionic pressure in the lymph as well as on the affinity for it possessed by the particular tissue in question.   Certain forms of malnutrition may depend not so much on the malabsorption of an inorganic ion as on the diminished affinity for that substance as the result of some intoxication or devitalisation of the living tissues.

But even when an ion is present in the lymph in a concentration greatly above its concentration in the cell, that substance is not absorbed in anything like the degree which one would expect of it, if one had regard only to its concentration over iso-tonicity. The living tissues have a "power of refusal."

This explains what is so well recognized, that it is impossible to oversaturate the tissues with any of the mineral substances— iron, arsenic, calcium, or even oxygen.   This fixedness of limit for saturation of protoplasm by chemical substances explains the impossibility of indefinite increase in bulk of tissues by overfeeding with nitrogenous food, of increasing the intensity of tissue-changes to any notable extent by the breathing of pure oxygen by healthy persons or of increasing, for instance, the iron or phosphorus content of the healthy red marrow or brain. After being satisfied, the tissues have a power of refusal—one of the expressions of "functional inertia."[1]

The same line of reasoning applies to the gases concerned in metabolism.   Thus oxygen must be under a certain pressure in order to enter properly into union with the living matter. Whereas oxygen at the partial pressure of one-fifth of an atmosphere suffices for the perfusion fluid for a frog-heart, it must be under the pressure of one atmosphere in the fluid[2] necessary for the mammalian heart.   In the actual blood, which could not take up anything like this quantity of oxygen in solution, this high pressure is functionally represented by the loose

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1, Harris, D. Fraser: The functional inertia of living matter. London, Churchill 1908.

2. Ringer-Locke solution consists of—
    NaCl, 0.9%   NaH CO3 0.01 to 0.0 3%
    Ca Cl2, 0.024% Dextrose, 0.1%
    K Cl, 0.042%
    Solution fed to the heart under the pressure of one atmosphere of oxygen.

chemical union of oxygen with the haemoglobin which dissoci-
ates in the neighbourhood of the living cells owing to the partial
pressure of oxygen in them being always zero. In the lung-
alveoli, oxygen is not present to more than 15 to 16% of an
atmosphere (that is 104 mm of mercury), and this pressure of
itself would be inadequate to drive the oxygen into solution in
blood-plasma to an amount sufficient for the respiratory needs
of the tissues, hence the blood possesses in its red corpuscles a
substance capable of uniting with the inorganic oxygen in such
a way that it can carry far more oxygen to the tissues than could
ever possibly reach them in solution in a colloidal protein sub-
stance like the plasma. It is of advantage to the body that there
be formed, therefore, complexes between proteins or protein-
derivatives and certain inorganic ions; and Dr. Creigh-
ton,[1] by having studied some of these in detail, has thrown a
good deal of light on their probable nature.

The whole of modern medicine is permeated by the notion
that bioplasm is affectable, that is, is capable of responding to
stimuli, a large number of which are chemical. Thus the
formation of an *anti*-body is only possible because there is a
reaction on the part of the affectable living matter to the
chemical stimulus of the foreign substance: if toxin be the
chemical stimulus, then antitoxin is the chemical response.
But the toxin must first come into chemical union with the
protoplasm else no antitoxin can result, just as the food mole-
cule must come into chemical relationship with the protoplasm
else no food could be absorbed.

The power of the proteins of blood-serum to absorb or take
up either acids or alkalies is of fairly high importance to the
bodily health. Thus, confining ourselves to the absorption of
acids only, if we add normal acid to blood-serum and use methyl
orange as an indicator, we shall have to add 0.18 c. c. of normal
$\left(\frac{N}{1}\right)$ hydrochloric acid to turn the indicator pink. If now we
titrate, similarly, the saline dialysate from the serum, the acid-

1. Creighton, H. J M. : loc. cit.

holding power is now only 0.04, so that $(0.18 - 0.04)$ 0.14% is the figure representing the acid fixed by the proteins alone. This represents 0.51% of hydrochloric acid itself. Now this is rather a considerable amount; and its physiological significance is that, within pretty wide chemical limits, no free acid can reach the living tissues, for the circulating proteins can combine with them and so constitute a protective mechanism against acidosis or an excessively acid condition of blood. These native or serum-proteins, therefore, behave in an amphoteric fashion, for they can fix alkalies like acids and acids like alkalies. This explains how serum is acid to phenolphthalein, and alkaline to methyl-orange, while it is physico-chemically neutral. This double power proteins possess is now believed to be due to their polypeptide composition. This means that after any number of amino-acids have united together in chain fashion, there will be left an amidogen group at one end and a carboxyl group at the other, thus conferring a chemical polarity or what is otherwise called "residual affinity."

Thus the dipeptide glycyl-glycin is formed,

$$NH_2CH_2COOH + H \ NH \ CH_2 \ COOH,$$

which gives us $NH_2 \ CH_2 .CO\text{-}NH\text{-}CH_2\text{-}COOH + H_2O$, a compound is basic on account of NH_2 and acidic on account of the COOH.

Hence owing to its acidity, glycin can form the copper salt thus

$$\begin{matrix} CH_2 \ NH_2 \ CO \ O \diagdown \\ CH_2 \ NH_2 \ CO \ O \diagup \end{matrix} Cu \ ;$$ and owing to its basicity it can unite
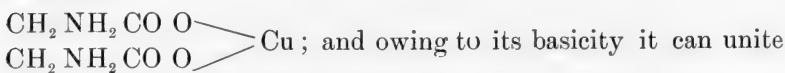
with an acid like benzoic and form hippuric acid thus;

$$C_6H_5 \ CO \ \overline{OH + H} \ NH \ CH_2 \ COOH = C_6H_5 \ CO \ NH \ CH_2 \ COOH + H_2O.$$

The union of oxygen with haemoglobin is, however, not merely an adsorption due to residual affinities, for it is strictly mono-molecular, and the reduced form of the pigment is different from the oxidised in colour and therefore in spectrum.

But not merely are acids and inorganic substances united

to the native proteins of blood, for 1% of fat is probably held in a quite invisible form in blood-plasma. This is exceeded by the liver which can hold as much as 5% of fat in a perfectly transparent and invisible form; the fat, for the time being, is chemically united to the tissue-proteins. Some physiologists hold that during the time that carbohydrate is in the liver, it is present in a protein-complex and they say that glycogen can be demonstrated chemically in liver cells before it can be histologically.

One of the latest views as regards the early fatigue of muscle is that potassium salts are detatched and sent into the circulation depressing the motor nerve-endings. What unloosens the potassium is not yet obvious, but it appears that potassium is set free. Lactic acid is similarly free in the circulation in the later stages of muscular fatigue.

That the union is ionic as regards certain inorganic substances is interestingly shown in the part played by calcium salts in the clotting of the milk. It is known that when the rennin has transformed the caseinogen into soluble procasein there is no precipitation of the latter until it has formed a union with calcium: a drop or two of calcium chloride now causes an abundant precipitation of casein. In 1895 I showed[1] that barium chloride and strontium chloride were equally efficacious. Here the action must be due to the divalent ions and to the different ions indifferently, for certainly the anion chlorine is not the causal substance. Now while this is so as regards the clotting of milk, barium cannot supplant calcium medicinally. In particular, barium chloride cannot replace calcium chloride as regards efficiency in maintaining the heart's rhythm. Barium is absorbed very slowly from the intestine, and when so absorbed is found to be a direct stimulant of muscle-fibre as distinct from nerve-fibre. Just as barium can replace calcium in the clotting of milk so it can replace it in the clotting of blood. Magnesium sulphate injected into rabbits gives rise to

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1 Harris, D. Fraser : Some points in the physiological chemistry and coagulations of milk. Pro. Roy. Soc. Edin., Session 1895-1896.

paralysis and anaesthesia and a low blood-pressure; it can be rapidly antagonised by either the chloride or the acetate of calcium, which revives the respiration in a surprisingly short time, but *not* by barium. It would seem as though in a non-vital union, barium and calcium were interchangeable, but not so in vital chemical complexes. Thus, the influence of magnesium is the same as that of calcium in inhibiting the spontaneous twitching of muscles immersed in solutions of sodium or lithium and in antagonising the contraction of skeletal muscle brought about by potassium salts; but in regard to its action on the heart, magnesium stands quite apart from calcium, barium and strontium, and is totally unable to replace these in the cardio-inhibitory mechanism or at the skeletal neuro-muscular junction.

And this is to a large extent comprehensible, for chemically, such substances as caseinogen, blood-germent, albumin, etc., and *not* to be taken as the equivalents of living matter, complicated as they are. The metabolism of calcium is full of lessons for us; one result of its presence in blood is to confer a certain degree of viscosity on that fluid. If there is too little viscosity, there is a tendency for the blood-plasma to exude too freely through the capillary wall so that an oedema or urticaria may be produced which is rapidly removed by the administration of a soluble salt of calcium—the chloride or lactate. It is possible that the tissues of haemophiles may suffer from a congenital inability to absorb or incorporate calcium. But indeed the whole doctrine of ionisation has been of great service in biology: for this may be taken to be the converse or the chemical condition of union of ions or atoms with the protein or living matter. Thus in the simple case of action of acids on living tissues, it is found that e. g. HCl is far more destructive to enzymes (except pepsin) than is acetic, the only satisfactory explanation of this being that HCl is far more perfectly ionised that acetic, not more than 3% of which is ionised. Since in regard to the effects of different acids, it is highly

unlikely that all the various anions $(Cl, NO_3, PO_4, SO_4, CH_3 COO)$ are the active substances, it is customary to attribute the physiological activity of the acids to the ionised H. Similary the alkalies, $(KOH, NaOH, NH_4OH)$ have only the OH ion in common, so that their common influence in activating enzymes is to be attributed to the anion hydroxyl. Hence, too, the "free" alkalies are physiologically more active than the carbonates, because they are more perfectly ionized. In some recent work of mine[1] on the presumed endo-enzyme, tissue reduction, any inhibitory action I found as the result of the presence of protoplasmic poisons was to be attributed rather to their acidity than to their so called toxicity; this is but one more verification of the statement that acids—H ions— destroy enzymes. Of course in all these problems we are dealing with very small quantities: the maximum concentration for the activating effect of alkalies is not greater than $\frac{1}{70}$th molecular. May the activity of certain dilutions not explain some of the results obtained in homoeopathy?

So much, then, for the sign of the ionic charge; we have still to reckon with the valency of the ion or the potential of the charge or the ionic potential.

Now the physiological activity of inorganic ions increases with their valency thus—Na^I, Ca^{II}, Fe^{III}; sodium being more bland than calcium and calcium than iron or conversely, iron is more active (toxic) than calcium, and calcium than sodium.

Much interesting work on the physiological activity varying with the valency has been done by my friend Mr. Mines, Fellow of Sydney Sussex College, Cambridge. Speaking of the H ion Mr. Mines writes:

"Concentration of H ions from .005 normal upwards, cause strong tonic contraction in skeletal muscle and a primary rise in electrical irritability, while the trivalent cations produce neither of these effects. On the other hand, the H ion shows striking resemblances in its action to that of the K ion. The

relative concentrations of H and K needed to produce similar effects on frog's skeletal muscle are in the ratio of 1 to 5, i. e. inversely as their ionic velocities."

And again he writes:

"So far from it being possible to ascribe the physiological action of various ions to some one factor such as solution tension, valency or ionic velocity, it must be recognized that one and the same ion may exert its influence on different tissues by virtue of different characters or groups of characters. Further, two ions, which from the point of view of one tissue exhibit constellations of properties which are much alike, may present wholly dissimilar aspects towards another tissue."

Mr. Mines adopts the view that tissues are to be regarded as "emulsoid (hydrophile) colloids."

These and similar researches are of the utmost value in bringing us towards the biologist's great desideratum—greater definiteness of conception regarding the living matter itself.

Our present point of view is that not alone in terms of pure organic chemistry are conceptions of the constitution of protoplasm to be framed. We are finding we must include in these the non-organic, the non-vital substances whose presence does not indeed constitute life, but in whose absence life cannot be constituted. As we have had in the past full demonstation of the importance of the structurally "infinitely little," so at the present time we are having, each day, fresh demonstration of the importance of the chemically infinitely little.

REPORT ON CAVE EXAMINATION IN HANTS COUNTY, N. S.— BY WALTER HENRY PREST, Bedford, N S.

Having been asked by the council of the N. S. Institute of Science to make some investigations into the anthropological possibilities of the caves in Nova Scotia, I submit the following as the result of a few days' work. A visit to three of the caves of Hants County gave information that may be worth recording, though it does not bear very strongly on the purpose of my visit. These caves were: Miller's Creek Cave, Frenchman's Cave, and Five-mile River Cave, all within easy reach of town and railway.

Miller's Creek Cave.—This cave is about $4\frac{1}{4}$ miles northeastward of the town of Windsor, Hants County, and about $1\frac{1}{4}$ miles north of the Midland railway. It is buried among steep hills near the headwaters of Miller's Creek, which here becomes only a dribble. A branch of the Miller's Creek road reaches the home of a man by the name of Connors, just back of whose house in the gulch in which is the cave. The original entrance is now nearly blocked by fallen rock, and the visitor is obliged to squeeze through a corkscrew-like hole in what was once the roof. Securing a guide, a lantern, and tools for use if the passage should be blocked, I entered an old quarry, at the end of which I climbed an immense pile of debris at the mouth of the cave. After sliding through the entrance backward, I found myself in a passage which had apparently once been about 30 feet wide and 15 feet high, but which is now choked almost to the roof by fallen rock. Descending to the level of the main cave the floor became more even and less littered with rubbish, and the roof higher. Then suddenly the cave expanded and a pond showed itself in the faint light of the

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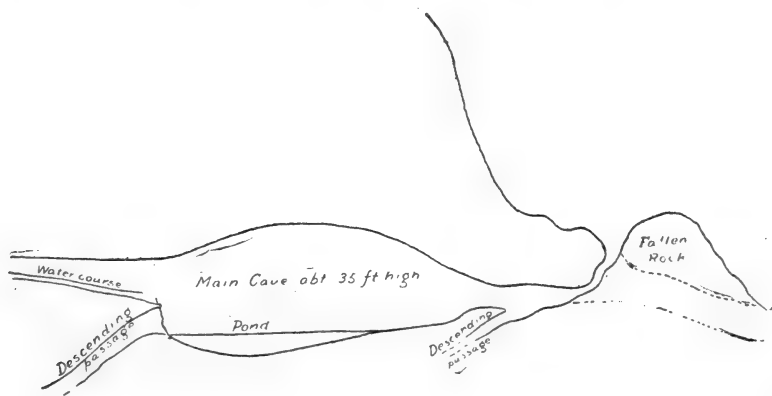
Miller Creek Cave
— Section —
from entrance to N W branch →
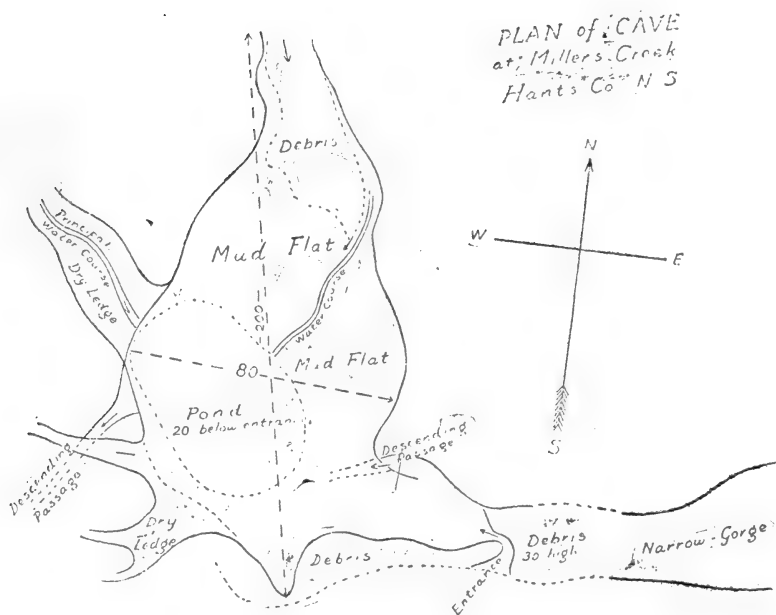
PLAN of CAVE
at Millers Creek
Hants Co N S

lantern. The rest of the floor of the cave was covered with soft mud so deep and sticky that it was almost impossible to travel through it. It had evidently been often overflowed, covering the sloping surfaces as well, with a coating of mud which made walking very difficult and insecure. The only dry ledges were on the southwest and northwest sides penetrated by small branches of the main cave.

The cave continued to the north, but was blocked to the roof in this direction by fallen rock. To the northwest was a smaller branch which probably penetrated farther than the others as it contained the main watercourse. I did not enter it as the ascent thereto was almost vertical and I was encumbered with the lantern. My guide refused to follow me farther than the entrance and I could not climb it alone. His conversation had been solely on ghosts and buried treasure and his absence was acceptable until this point was reached. The overflow from the pond, which was only 3 or 4 feet deep, was through a small slanting passage on the west side which descended to a lower level. The southern end of the cave, like the northern, was piled high with debris from the roof. Most of the branch passages were but from two to five feet high. The main cave is nearly 200 feet long, 80 feet wide, and probably 35 feet high in the centre. The annual freezing and thawing continually adds to the obstructions at the mouth of the cave and will in time doubtless make the entrance impassable. The inhabitants of the locality tell me that within their memory the passage was large enough to walk through upright.

I was convinced that the cave in its present condition never was a human habitation, though it may have been a refuge from storm or a hiding place from an enemy. However, when the land was higher the torrents may have kept the place cleaner, but just now the only places in the interior of the cave

that could furnish spots dry enough for habitation are the branch passages to the northwest and southwest. The extremely thin deposit on these ledges may perhaps yield human relics. The original entrance, now buried beneath from 20 to 30 feet of debris, would probably yield something of interest, though the cost of removal would be great.

Frenchman's Cave.—This cave is situated ¾ mile northeast from the village of St. Croix, Hants County, in the rough gypsum land to the east of the river.* This tract of land is full of sink-holes, some of which are now being formed to the detriment of the farms. One man spent much time trying to fill a newly formed hole with stones, but gave up the attempt after much labor. In the neighborhood of the cave it is hard to find a path among the numerous sink-holes, evidence of course of caves beneath. In one of these sink-holes is the entrance to the Frenchman's Cave, where it is claimed that the Acadian French hid their wives and children and buried their treasure in the days of Evangeline. Many other tales are connected with it, some based on fact but grossly exaggerated, some uncanny with superstition, and others simply ridiculous.

After travelling through a tract of very rough land, my guide led me down one of the numerous sink-holes, where at a depth of 35 feet we found the entrance to the cave. This was about 20 feet wide and 7 or 8 feet high and ran in a westerly direction. Its easterly extension was blocked by the fall of rock when the roof gave way. A large number of sink-holes farther east indicated its course. A small stream ran through the cave, which in rainy weather became a torrent, preventing entrance. I followed the cave about 150 feet, where it became only 2 feet high, becoming still less farther on. The bottom was small pebbles and mud. I was told afterward that one could penetrate several hundred feet to some larger rooms by crawling through on his stomach in dry weather.

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* This cave is situated on the north bank of Wier Brook, a branch of the St. Croix River.

As a human habitation, even for the lowest savages, it seems to be out of consideration, owing to its susceptibility to floods, and the limited floor space above the water or mud level. It might, however, have furnished a refuge for a limited number of people for a short time. I therefore dismissed the idea that it had any archæological value in spite of the entertaining stories told about it.

Five-mile River Cave.—This cave is situated in Hants County on the south bank of the Five-mile River, a western tributary of the Shubenacadie. It is $\frac{1}{6}$th mile south of the Midland railway, the nearest stations being South Maitland ($2\frac{5}{8}$ miles) and Burton's ($2\frac{1}{8}$ miles). The river, green hills, and towering white gypsum cliffs give a wildness and beauty to the surroundings not often seen outside Nova Scotia. Nearly half way up the pure white cliffs, is the mouth of the cavern. The mouth is wide and easy of access, being reached by an inclined plane of debris fallen from the cliff. It is, however, being slowly blocked up by rock as the fall of the friable and frost-riven gypsum is yearly adding to the obstruction. The entrance is probably 20 feet wide and 7 or 8 feet high, but the oldest inhabitants tell me that it once was over 20 feet high. The river, which once kept the face of the cliff clear, has long since been diverted to the opposite side of the narrow valley.

Procuring a guide and a couple of lanterns, I descended the pile of fallen rock at the entrance, and penetrated about 250 or 300 feet before lighting the lanterns. Here I stood beneath a vast dome over 150 feet wide and 60 feet high. On the left were several ponds and water-holes, deep and transparent, reaching to the wall. On the right was a slope of broken rock reaching to the right wall and almost to the roof. Proceeding, the lower part of the cave became muddy while the roof became higher and the cave wider. Near the first sink-hole it must have been nearly, if not quite 200 feet wide, and the white gypsum roof stretched almost flat, without a support, from one

side to the other.   Great blocks of gypsum littered the floor
and finally compelled us to climb over them or squeeze through,
between, or beneath them.   In climbing over the boulders, the
guide fell and put one of our lanterns out of commission.   In
so large a cave this was a great inconvenience, as the narrow
circle of light from the remaining lantern did not reach to either
wall.   The wide and slightly arched roof continued for over
1000 feet.   Spreading from wall to wall without a single
support it seemed to me a marvel of natural architecture.
About 1300 feet from the entrance, the cave became so
obstructed by enormous blocks of gypsum that a passage was
hard to find.   Many apertures were entered, followed a few
yards, and retraced.   Then others were followed up, down, or
laterally.   Some ended in diverging fissures, too small to be
followed.   The last, only 15 inches wide, ascended at an angle
of 60° and became impassable.   Even here the cave was large,
but blocked from bottom to top by a jumble of fallen rock that
prevented all further progress.   The extreme length, as far as
passable, is about 1600 feet.

The archæological value of this cave is much reduced by
the enormous quantity of rock continually falling from the roof
and cliff outside.   In its original condition it was doubtless
an ideal place for shelter, and was probably so used by the
aborigines.   Now there is probably 30 or 40 feet of debris over
the original floor at the mouth of the cave.   Probably nearly
all the caves in the gypsum region are in the same condition,
this friable rock rapidly crumbling under the influences of frost
and heat.

Geological Conditions.—That the origin of these caves
reached back to a time when this province was much higher
than now, there is no doubt.   Some evidence for this view is
furnished by the springs that come up from the bottoms of
rivers at tide-level, such as are seen in the River St. Croix
above the bridge on the road leading from St. Croix to Brook-

PLAN of CAVE
at Five Mile River
Hants Co N S

Five Mile River Cave
- Section at Entrance -
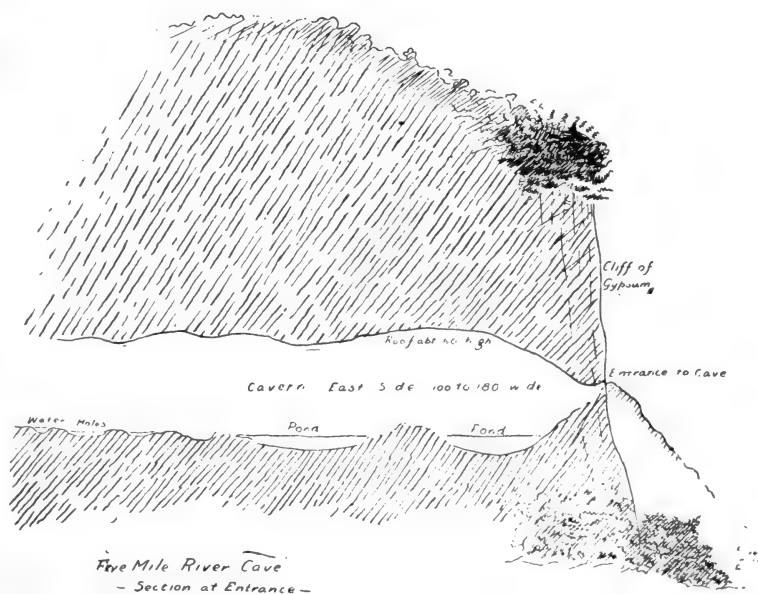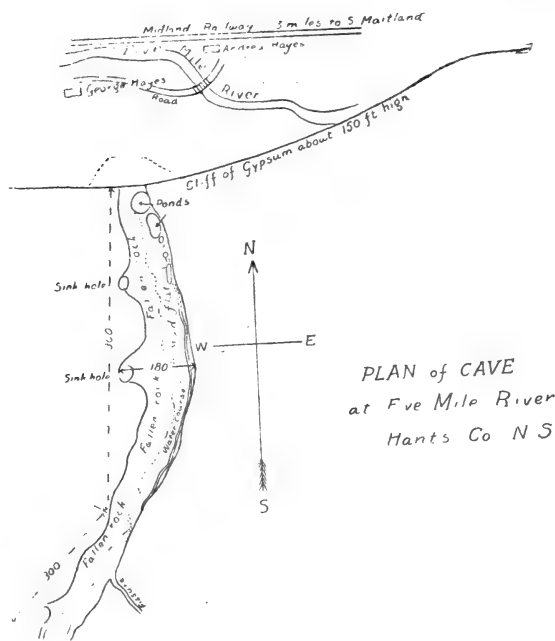
lyn. In some places the gypsum is honeycombed with caves below the tide-level. Springs sometimes burst out in estuaries and tidal-flats as at Shubenacadie.

If we place the gypseous origin of the rock in question in the Triassic age, a time of great seismic disturbance, we have the whole of the long period since that time for the various phases of cave formation and destruction. There has been elevation, excavation, denudation (aerial and sub-aerial), and finally subsidence. A former covering of gypsum has been removed from a large tract of country, and former caves obliterated, now traceable only by narrow valleys or preciptuous gulches. Existing caves are located by strings of sink-holes, which latter are growing larger and more numerous as years go by. The gradual subsidence of the province has placed many of these caves beyond reach, and, according to the best evidence, this subsidence is still going on, unless it has very recently reached its lowest point. It may be mentioned that the three caves I have described, are located in formations of carboniferous limestone (the Windsor series).

A Rearrangement of Procedure for the Removal of Phosphate Ions from the Iron and Alkaline Earth Groups.—By Carleton Bell Nickerson, M. A., Instructor in Chemistry, Dalhousie University, Halifax, N. S.*

The following procedure is the result of several attempts to simplify the various methods in common use for the removal of phosphate ions during the qualitative separation of the metals of the iron and alkaline earth groups. It has been the author's experience that, for the usual college class in qualitative analysis, the methods commonly used require rather too much nicety in manipulation to be altogether practicable. The procedure given below has been used by the class in qualitative analysis at Dalhousie University this year with very favorable results.

1. *Procedure.*—Treat the solution (after the removal of all the metals precipitated by H_2S in acid solution) with a few drops of conc. HNO_3 and boil until all H_2S is expelled; filter if necessary. Add at once about ⅓ volume of strong NH_4Cl solution and a *slight* excess of NH_4OH. Filter:

Notes.—1. The HNO_3 is added to oxidize any iron that may be present, which after the H_2S treatment is always in the ferrous condition.

2. The treatment with HNO_3 may also cause a slight precipitation of sulphur from the H_2S.

3. Care must be taken to avoid adding more than a slight excess of NH_4OH, since the precipitate of $Al(OH)_3$ is somewhat soluble in an excess.

3. The precipitate with NH_4OH under ordinary conditions would consist only of hydroxides of Fe, Al and Cr. If however PO_4''' ions are present, it may also contain phosphates of the above metals and also of Ca, Ba, Sr and Mg.

2. *Procedure.*—Dissolve a small portion of the NH_4OH precipitate in HNO_3 (Sp. g. 1.2) and test for PO_4''' ions with $(NH_4)_2MoO_4$. If a yellow precipitate forms, dissolve the remaining portion of the precipitate in dilute HCl (Sp. g. 1.12). Test a small portion of the solution for Fe with $K_4Fe(CN)_6$. To the remaining solution add $FeCl_3$ solution, drop by drop, until (after careful stirring), a drop of the solution removed by means of a stirring rod gives a *brown* precipitate of $Fe(OH)_3$ with NH_4OH on a porcelain plate.

Notes.—1. The test for Fe must be made at this point since $FeCl_3$ is added to the solution later on.

2. The addition of $FeCl_3$ causes a precipitation of $FePO_4$ (white) when the solution is made alkaline by NH_4OH. When a sufficient amount of $Fe^{..}$ ions has been added to combine with all PO_4''' ions, an excess of $FeCl_3$ causes a precipitation of the brown $Fe(OH)_3$

3. *Procedure.*—To the HCl solution containing an excess of $FeCl_3$ add NH_4Cl solution and a slight excess of NH_4OH. Filter. Save the filtrate.

Notes.—1. After the addition of NH_4OH, the precipitate will contain, $FePO_4$, and hydroxides of Fe, Cr, and Al, all the PO_4''' ions remaining in the precipitate. The filtrate may contain ions of Mn, Ni, Co, Ba, Sr, Ca, and Mg.

4. *Procedure.*—Dissolve the above precipitate in dilute HCl (Sp. g. 1.12) and add an excess of $NaOH$ and H_2O_2. Filter.

Notes.—1. By the addition of $NaOH$ and H_2O_2 the $Al(OH)_3$ is converted into the soluble Na_3AlO_3, and the $Cr(OH)_3$ is oxidized to Na_2CrO_4, the iron precipitate remaining behind on the filter.

5. *Procedure.*—Divide the above solution into two parts, and to one add an excess of $HC_2H_3O_2$ and a few cc. of $Pb(C_2H_3O_2)_2$ solution.   A yellow precipitate indicates Cr. To the other portion add an excess of dilute H Cl, and then a slight excess of $N H_4O H$.   Warm and set aside.   A white flocculent precipitate is $Al(O H)_3$.

6. *Treatment of filtrate from* 1.—Acidify a small portion of the solution with dilute HNO_3 and test for $P O_4'''$ ions with $(N H_4)_2MoO_4$ If a yellow   precipitate is formed, treat the remainder of the solution with H_2S.   A white precipitate is ZnS.   If no PO_4''' ions are found, see 7.

Notes.—1.   The addition of even a slight excess of $N H_4O H$ in 1, is sufficient to convert the Zn into the soluble complex compound $Zn(N H_3)_4(O H)_2$, which passes through into the filtrate and is removed by H_2S.

2., If the addition of $(N H_4)_2MoO_4$ shows the presence of $P O_4'''$ ions, then the solution after the removal of Zn contains only the metals of the alkali group.

7. *Procedure.*—If $P O_4'''$ ions are not found in 6, add solution to filtrate from 3, warm, and to the warm solution add an excess of H_2S.   Filter:

Notes.—1. If $P O_4'''$ ions are not found in 6, the solution will contain only those ions in excess of what was necessary to combine with the $P O_4'''$ ions precipitated in 1. They may consist of: Zn, Mn, Ni, Co, Ba, Sr, Ca, Mg, K and Na.

8. *Procedure.*—Treat precipitate with a small amount of dilute H Cl (1 part H Cl 1.12 to 5 parts water).   Residue may be Ni S and Co S.   Separate in usual way.   Treatment of

H Cl solution : Add an excess of Na O H. Filter and fuse the precipitate with Na_2CO_3 on platinum foil. Green color indicates Mn. To filtrate add H_2S. White precipitate is Zn S.

Notes.—1. An excess of Na OH forms a soluble compound with the Zn, $Na_2 Zn O_2$, which passes into the filtrate. The Mn is at the same time precipitated as Mn $(O H)_2$ and converted by fusion with $Na_2 C O_3$ to the compound $Na_2 Mn O_4$, which is green in color.

9. *Procedure.*—The filtrate from 7 now contains only the ions of the alkaline earth and alkali groups. These are separated and identified in the usual manner.
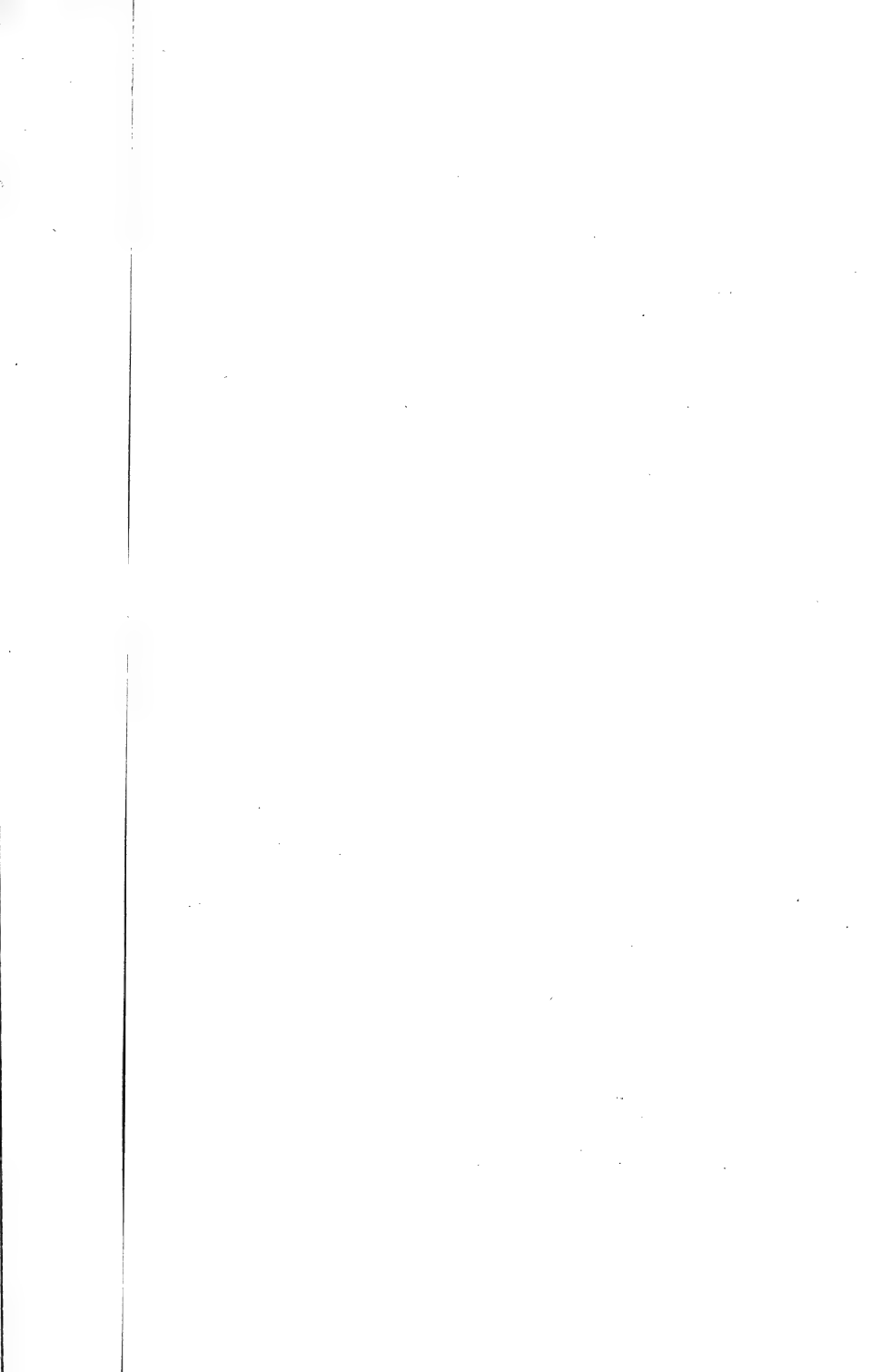
BRIEF ACCOUNT OF THE MICMAC INDIANS OF NOVA SCOTIA AND THEIR REMAINS.—BY HARRY PIERS, Curator of the Provincial Museum of Nova Scotia, Halifax, N. S.

The following paper has been prepared for the purpose of presenting in a concise and systematic form some general information regarding the native tribe of Nova Scotia, and it is hoped it may be useful at least for ready references, as the writer does not know of anything dealing with the whole subject in just this way. He hopes at some future time to expand these brief notes into a paper which will deal with the subject more in retail. The bibliography which is appended, although not exhaustive, will assist in placing students in touch with most of the available sources of information.

Location.—The Indians of Nova Scotia belong to the Micmac tribe which is an important branch of the Algonquian family. Besides this province they inhabited Prince Edward Island, the northern part of New Brunswick and probably parts of southern and western Newfoundland. In New Brunswick they came in contact with the Malecite tribe, another branch of the same family, and in Newfoundland they occupy a region once inhabited by the extinct tribe of Beothuks, which latter is now regarded as a distinct family by itself.

Name.—The Micmacs call themselves _Megumawaach,_ and the name Micmac evidently is a corruption of this.* J. N. B. Hewitt gives the meaning of _Migmak_ to be 'allies'. The Micmac name for an Indian is _Ulnoo._ The French called the tribe _Souricois_ or _Souriquois*_ (Champlain, 1603 ; Lescarbot, 1609) ;

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* According to my notes made from the pronunciation of Chief Noel, the Micmac name for the tribe is _Meegamauk_ and for any Indian, irrespective of tribe, _Ilanoo_ or _Ilanoo(k)._ Ilanoo or Ulnoo originally meant "a man" generally.

but among the English they have mostly been called Micmacs, and we find the name in use in 1696 (*N. Y. Doc. Col. Hist.,* ix., 643). Gatchet speaks of *Mikemak* (singular *Mikema*) as their Penobscot name. Malecites seem to have called them *Matu-es-wi skitchi-nu-uk,* meaning 'porcupine Indians', on account of their using porcupine quills in ornamental work (Chamberlain, Malecite MS., Bur. Am. Eth., 1882).

History.—The Micmacs seem to have been a fierce and warlike tribe, subsisting chiefly on the products of the chase. They soon became the loyal allies of the French who settled in Nova Scotia in the beginning of the seventeenth century, and there was more or less intermarriage between these settlers and the tribe, which more firmly cemented the bonds between them. When the English began to occupy Nova Scotia after the capture of Port Royal (Annapolis) in 1710 they found the Micmacs a great source of annoyance, as they naturally took the part of their old allies and lost no opportunity of harassing the British, and it was largely owing to their inroads that settlement of the country did not progress more rapidly. After the deportation of the Acadians and the fall of Quebec the English succeeded in making treaties with the tribe in 1760 and 1761, which permitted the clearing and settlement of the land to go on more peaceably than formerly, but it was not until 1779 that the disputes finally ceased, and from that time they could be spoken of as loyal to their new masters. Since then their history has been uneventful. Early in the nineteenth century a chief Indian commissioner (Monk) was appointed, and in 1842 an Indian commissioner (Howe) again held

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*I am not quite certain of the derivation of the French name Souriquois. Des Brisay, (*History of Lunenburg,* 1st ed., p. 150), says the Micmacs were called by the French, "Souriquois, or salt-water men." The *Century Cyclopedia of Names* says the tribal name Souriquois, was one imitating words meaning "good canoe-men" (the derivation of which I fail to see, if from the Micmac language) ; and the same work, on what authority is not mentioned, states that *Micmac* is translated as "secrets-practicing men," alluding to Shamanistic jugglery. Surenne (*French Dictionary*) says *souriquois* is a term used to describe "a mixed tribe"; and in Spiers and Surenne the definition is given of *mice, micy* ("peuple souriquois," *micy tribe*), but this probably has no connection with the use of the word to denote the Micmac tribe. The Beothuks called the Micmacs *Shanock,* "bad Indians," (*Journ. Anthrop. Inst.,* iv, 29, 1875.)

office in Nova Scotia, and was followed later by Col. Chearnley, but soon after confederation supervision was transferred to the Department of Indian Affairs at Ottawa.

Early Conditions.—In prehistoric times the Micmacs had made but slight advancement towards civilization, in this respect being behind some of the Indians of Ontario. They apparently did not cultivate Indian corn, but lived almost entirely by the chase and fishing, and delighted in war. In summer-time they dwelt mostly on the coasts and in winter retired to the more sheltered interior. They made various stone implements, canoes, snowshoes, a very few small copper implements, rough pottery (poorly burnt, with occasional attempts at rude ornamentation), and they produced some rude pictographs upon rocks. A few implements of unmistakable southern workmanship indicate that they traded somewhat with other tribes, although they may have been obtained by conquest.

Marc Lescarbot, who met with the Micmacs during his residence at Port Royal (Annapolis Royal) subsequent to 1606, gives in his *Nova Francia* (first published in 1609) an excellent account of the Souriquois as he found them in his day, and this description is one of the best of the earliest ones we have of their manners, customs, etc., at a period when iron implements were only just beginning to supplant those of stone. He says they wore a skin breech-cloth attached to a leather girdle, and a cloak of otter, beaver, moose or stag, bear or lynx, tied up with a leather thong, and one arm was usually thrust out. In their wigwams this cloak was laid aside, unless it was cold. The women wore a girdle about the cloak. In winter they wore "good brave sleeves, tied behind, which keep them very warm." In winter, going to sea, or hunting, they wore long leggings, cut into a great number of points on the side of the leg, and tied to the belt. On their feet they wore moccasins of mooseskin. They had no head-dress, but men and women wore their

hair loose over their shoulders, the men trussing it upon the
crown of the head, some four fingers length, with a leather
lace, which they let hang down behind. Lescarbot says, "All
those I have seen have black hair, some excepted which have
Abraham [auburn] color hair." They greased their bodies and
anointed their shoulders with oil, to defend them from trouble-
some flies. They wore *matachias* hanging at their ears, and
about their necks, bodies, arms, and legs. These the women
made of porcupine quills dyed black, white and red. They
more esteemed matachias made of shells by the Armouchiquois
(Indians of New England), which were difficult to get owing
to the continued wars between the tribes. Matachias of quills
of glass, interspersed with tin or lead, were traded with them
by the French. They passed their time in war or hunting, or
making implements therefor, or in play. Their bows were
strong and without fineness. Lescarbot marvels at how long
and straight they could make their arrows with a stone when
they had no metal knives, and these they feathered with
feathers from the eagle's tail. Such as had traffic with the
French headed the shaft with iron. They had quivers, and their
bow-strings were made of intestines, and snowshoes or racquets
were strung with the same material (Denys says with thongs
of moose-hide). They also had wooden clubs "in the fashion
of an abbot's staff" and shields which covered all their body.
They bartered with the French for fishing lines and hooks.
Canoes were made of birch-bark, and they "also make some of
willows very properly which they cover with gum of the fir-
tree." The French writer tells us that anciently they made
earthen pots and also did till the ground, "but since that
Frenchmen do bring with them kettles, beans, pease, bisket
and other food, they are become slothful, and make no more
account of these exercises." It was found by experiment that
they had rather go without bread than have the trouble of
grinding corn. The women peeled birch-trees for bark for their

wigwams, and labored at making canoes, etc., while the men "do play the gentleman, and have no care but in hunting, or of wars"; yet the women commonly love "their husbands more than the women of these our parts." Lescarbot once saw an Indian boil meat in a trough formed of a tree-trunk, into which he placed red-hot stones; and I may say that they also cooked thus in birch-bark receptacles. (See Relics of Stone Age, *Trans. N. S. Inst. Sc.,* ix, pp. 27-31). The missionary Biard, in his *Relation* of 1616, also gives an account of the Micmacs of his time, and states that they did not till the soil. The fullest account of their dress, manners and customs is to be found in Denys' *Description des Costes de l'Amerique septentrionale* of later date, 1672. (See Ganong's translation, 1908).

It is sometimes asked if Nova Scotian caves contain any evidence of having been occupied by prehistoric Micmacs or their predecessors. In order to investigate this question to some extent, an exploration was recently made of three gypsum caves in Hants county, but so far with negative results, although the large amount of rock debris in these caves would probably have hidden or obscured such evidence if it were there. (See Prest, *Trans. N. S. Inst. Sc.,* xiii, pp. 87-94).

No data is available regarding measurements of Micmac skulls, etc., whereby we might compare them with those of other tribes. There are ancient burial-places at Indian Gardens, Fairy Lake, etc., that would furnish material for such work. (See Prest, *ib.,* pp. 35-39).

Present Condition.—The Micmacs now live by acting as guides for sportsmen, and by making axe-handles, baskets, tubs, porcupine quill-work, and various odds and ends, and some of them cultivate a little land, having small houses on reservations but mostly going into conical birch-bark wigwams or "camps" as they are called, in the summer. Most of them have to eke out their slender means by asking alms. Birch-bark canoes are

now less frequently seen. They still occasionally make their own snowshoes. In the past they have been much decimated by smallpox, and consumption is prevalent among them, while drunkenness has been a great curse to them, but less so than formerly. The children when infants are strapped in a peculiarly shaped cradle, which is slung on the mother's back, or suspended from a tree. The children are taught obedience and respect to their parents. Women are accounted inferiors to the men.

Recent Dress.—Up to within comparatively recent years the men clothed themselves in a dark blue broadcloth coat ornamented with scarlet or other brightly-colored silk borders, scarlet cloth pipings in the seams, and elaborate coloured-beadwork extending across the upper part of the shoulders and on "wing"-like shoulder pieces, as well as on the cuffs and front boarder, and the coat was girded in by a red sash. With this were worn trousers of the same kind of cloth, with a row of narrow-cut tags up the outside seams. A high silk hat and low moose-hide moccasins completed the men's costume in those days. The chief and other officials still appear in such clothes (omitting the silk hat) on formal occasions, and the chief also at times of great ceremony wears a headdress of eagle-feathers. I am informed that the chief at Shubenacadie (?) has the equivalent of a "wampum" belt, which is hereditary in the office. I have not seen it, but it is described as being composed of various dark-coloured pierced stones strung on sinews or a leathern thong, and it is said to have some symbolic meaning, or tells some story, although there are few if any of the Indians who can now interpret it although some have an obscure idea of its signification.* Other heirlooms or insignia descending to each

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*Reference to this belt is made on the authority of one Indian, and I have had no opportunity of verifying the statement which must be take with some doubt. Chief Noel never referred to the belt, although he showed me his other insignia of office. It was not among the chief's official effects which were forwarded to the Archbishop of Halifax on Noel's death in 1911. Dr. Rand, however, refers to a wampum belt on page 81 of his *Reading Book*, saying "as marked on the 'wampum belt.' [the chief's district of] Cape Breton is at the head." It is possible that the belt is in Cape Breton.

of the Shubenacadie chiefs, are a silver medal of 1814, presented by George III. to the then chief, and a large gilt medallion presented by a former Pope. The women formerly wore pointed cloth caps (*abedowargosen*) elaborately ornamented with coloured beadwork; loosely-fitting, brightly coloured satin jackets (*mardelit*) with red or other coloured borders bedecked with beads; and skirts of dark blue broadcloth prettily embellished on the lower parts with numerous broad horizontal bands of silk of various colours, in parts cut into pointed forms, and more sparingly ornamented with beads and spangles. Ornamental broadcloth leggings were also worn with the skirt. The older women are still sometimes seen in this characteristic costume, but it was once the regular dress of the women of the tribe. It may be observed that the pointed headdress is depicted on old petroglyphs at Fairy Lake. (See Report on Provincial Museum for 1910).

Chiefs.—The province is divided into five districts, each of which has a chief, the one with which Halifax comes most in contact with being he at Shubenacadie. Rand (*Reading-book in Micmac*, 1875, p. 81) says the Indian name for the whole country, is *Megumaage* (Micmac-land), and he says it was divided into seven districts (including two in New Brunswick), each district having its own chief, but that the chief in Cape Breton, which comprehended one district, was looked upon as head of the whole. The seven districts as given by him were as follows: Cape Breton, Pictou, Memramcook (in New Brunswick), Restigouche (in New Brunswick), Eskegawaage (from Canso to Halifax), Shubenacadie, and Annapolis district reaching to Yarmouth. Chief John Noel of Shubenacadie informed me that the jurisdictions of the several chiefs in Nova Scotia are as follows: (1) The chief at Shubenacadie has jurisdiction over Halifax, Lunenburg, King's, Hants, Colchester and Cumberland counties, and he claimed that he was considered to be the head chief, perhaps the result of his having

been located nearest to the seat of the provincial government;
(2) the chief at Bear River has jurisdiction over Annapolis,
Digby, Yarmouth, Shelburne and Queens counties; (3) the
chief at Pictou has control of Pictou county; (4) the chief at
Pomquet presides over Antigonish and Guysborough counties;
and (5) the chief at Eskasoni governs the whole of Cape Breton
Island. Besides these there are chiefs in Prince Edward
Island and in parts of New Brunswick. The chief has the
settling of such disputes as may arise among the members of
the tribe, and I do not know of an instance of an Indian
bringing his case to one of our own courts. The chief is elected
at a gathering of the tribe, much discrimination being exercised
in the choice; and he receives a ratification of his appointment
from the Governor, pledges allegiance to the Sovereign, and
goes through a certain religious ceremony performed by the
Roman Catholic Archbishop. Under the chiefs are captains
and majors.

Reserves.—Throughout the province are certain areas of
land reserved for Indian occupation. Some of these are so
used for that purpose, others are not. Schools are located in
some of the reserves.

Numbers.—Biard in 1611 places the number of Micmacs
at from 3,000 to 3,500. In 1760 they were estimated at nearly
3,000, having dwindled by sickness. In 1766 we find them
enumerated at 3,500. It may be noted that New Brunswick
and Prince Edward Island then formed part of Nova Scotia.
In 1842 Howe reported their number to be 1425. In 1851
they were returned as 1,056, which was probably an under-
estimate. The Nova Scotian census of 1861 (the first accurate
one) gives the number as 1407. In 1871 they numbered 1,666
in this province; in 1881, 3,892, of which 2,125 lived in Nova
Scotia; in 1884, 4,037, of which 2,197 lived in Nova Scotia;
in 1892, 2,151 lived in Nova Scotia; in 1901, 1,542 were in
Nova Scotia; and in 1904 (Indian Report) they numbered
3,861, of which 1,998 were in Nova Scotia, 992 in New Bruns-

wick, 579 in Quebec Province, and 292 in Prince Edward Island. In 1905, 1,993 were in Nova Scotia; in 1906, 2,148, and in 1911, 2,026.

Language.—The language of the Micmacs is a branch of that of the Algonquian tribe. William Jones of the Field Museum of Natural History, says that while their neighbours, the Abnaki, have close linguistic relations with the Algonquain tribes of the great lakes, the Micmacs seem to have almost as distant a relation to the group as the Algonquains of the plains. The Micmac, like many, if not all, of the native American languages, is remarkable for its copiousness, its regularity of declension and conjunction, its expressiveness, its simplicity of vocables, and its mellifluence. In all these particulars and others, it is said not to suffer from a comparison with the learned and polished languages of the world. One pecularity is that it is what philologists term holophrastic, a whole sentence being sometimes condensed into a single word. This, while it wonderfully shortens speech, greatly multiplies words. For example, Rand instances the sentence, "I am walking about, carrying a beautiful black umbrella over my head," comprising twelve words and twenty-one syllables, all of which can be expressed in a single Micmac word of ten syllables, *yale-oole-maktawe-pokose.* (See preface to Rand's *Dictionary*). The usual place for the accent is on the penultimate syllable, while a prolongued vowel is of course accented. Micmac words are extremely soft and melodious when pronounced by the Indian, being entirely without the harshness which results when a white man attempts to reproduce them, and even a dictionary tends to harshen them when they are represented by letters of our alphabet. It is this that has often made people think the language an uncouth one. The Micmac names of places are beautifully soft in sound and poetic in idea, and it is the greatest pity that we have not retained more of them instead of the meaningless European names we have too frequently scattered throughout the province. In such Micmac place-

names as we have kept, we have unfortunately greatly harshened the sounds, through our ears failing to appreciate the soft illusive sounds of the native's syllables. The late Dr. Silas T. Rand was the foremost student of the Micmac language, and he published a reading-book and a dictionary, as well as many biblical translations.

Religion.—We know practically nothing of assurance regarding their pre-historic religious beliefs, except that through legend we find that they paid high respect to and almost worshipped a superhuman being, in the form of an Indian, called *Glooscap.* He was benevolent, exercised a care over the Indians, was supposed to live in a wigwam, where an old woman kept house for him, and a small boy fairy was his servant. It was believed he could transform mortals and that he possessed other wonderful powers. He and his attributes are frequently mentioned in their legends, and the Indians suppose he is still in existence. (See Rand, *Legends of Micmacs,* p. xiv et seq.) Father LeClercq in the seventeenth century invented a series of hieroglyphs for use among the Micmacs, and these characters were employed in the printing of Micmac religious works by the Rev. C. Kauder. A page of LeClercq's Lord's Prayer in these characters is reproduced in Pilling's *Bibliography of the Algonquian Language,* opp. p. 305. In 1846 the Rev. S. T. Rand, a Baptist clergyman, took up the life of a missionary among the Indians, and as a result a Micmac Missionary Society was established, and Rand translated into the native language the greater part of the Bible. The official returns now give all the Micmacs as belonging to the Roman Catholic Church, the one with which they first came in contact about 1604, and to which they have since been firmly attached. They have an annual religious festival on St. Ann's day, which is perhaps less fully observed than in former years.

Legends.—They have a large amount of legendary lore relating to Glooscap, his followers, and various personified

animals, etc., all of great interest, which has been collected in Rev. S. T. Rand's *Legends of the Micmacs* (New York and Lond., 1894), to which I must refer those interested in this very attractive subject.

Mortuary Customs.—Since the advent of Europeans, at least, the Micmacs have buried their dead in the ground, although I was told by Chief Noel* and other Indians, that in prehistoric times (perhaps under certain circumstances) they placed the corpse, wrapped up, in a tree or on a staging, and I find that Denys (page 438 of Ganong's edition) confirms this tradition and describes in detail their old burial customs. Unfortunately, no proper scientific examination has yet been made of pre-historic burials, to ascertain exactly the manner of burial, although Dr. Patterson has a few words to say regarding this subject (*Trans. N. S. Ins. Nat. Sc.,* vii, p. 231 *et seq.*). There is no doubt, however, from such old graves as have been opened, that various implements and utensils were placed along with the dead.

Games.—Some games survive from pre-historic times. One of them, the most popular, is known as Indian dice (*altestakun*) and is played with six bone or walrus-ivory disks, flat on the upper side and slightly convex on the other, inscribed with characteristic curved lines, forming a figure resembling a star or Maltese cross, for ornamental or symbolic purposes. These are tossed on a shallow wooden platter, and according to the result the player gets little stick counters, of which there are 55 in all, a few of which (of greater value than the rest) are of different shape from the remainder. A similar game

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*Since this paper was written, John Noel, the venerable chief of the Micmacs of Halifax, Lunenburg, King's, Hants, Colchester and Cumberland counties, died at the Indian reservation on Spring Brook, near Shubenacadie, on 20th May, 1911. He had been born at Pictou on 3rd May, 1829. He was highly esteemed by the tribe over which he presided and by the white men with whom he came in contact. He had always taken interest in matters relating to his people's history, and the writer is indebted to him for valuable tribal tradition and other information and recalls with pleasure many hours spent in conversation with him on such topics. Noel had succeeded his stepfather Chief James Paul, who had probably succeeded his uncle Francis Paul, who had succeeded Chief Samuel Paul (also known as Benjamin Paul).

(*wabanokank*) is played with eight slightly larger disks or like form and ornamentation, which are tossed by the hand upon a spread blanket or cloth. Still another game (*comugesjokonk,* i.e. "to play little sticks") is almost the counterpart of the European game of jack-straws, and may be of European origin, although the Indians themselves claim it as a native game.

Pre-historic Implements.—There are only two important collections of Nova Scotian Indian relics of the stone age. The principal one is in the Provincial Museum of Nova Scotia, Halifax, and embraces (*a*) miscellaneous implements and other relics deposited therein since 1831; (*b*) the collection of the late Judge M. B. DesBrisay, of Bridgewater, N. S.; (*c*) the collection of the late C. W. Fairbanks; and (*d*) the collection of the late Dr. W. Webster. The total number of specimens in these four collections is now 1287. The next largest collection is that of the late Rev. Dr. Geo. Patterson, of New Glasgow, N. S., presented by him to Dalhousie College, Halifax, and containing about 250 specimens. There are also several other specimens there, donated by the late Dr. Thomas McCulloch. All of these have been described except the Des-Brisay collection.

Relics of the stone age are uncommon in Nova Scotia, in marked contrast to the large number that are found in Ontario and to the south, and this no doubt indicates that Nova Scotia had been occupied for a much shorter period than those parts, or that the inhabitants were much fewer for the area.

Another point to which I desire to draw attention is the great probability that many of the implements found in this province are really remains of a period when the country was occupied by Eskimo. Tradition affirms that the Micmacs coming from the southward drove the Eskimo northward, and this is borne out by evidence obtained from the implements. Among the Algonquians, to which family the Micmacs belong, the axe-method of hafting was common, and to the south axes

are frequently found and form a fair proportion of the imple-
ments met with in collections. In this province, on the
contrary, stone grooved-axes are rare; and in their places we
find an unusual number of adze-shaped implements, intended
to be hafted as adzes. Now, this latter method of hafting is
very prevalent among the Eskimo, so much so that they have
taken a modern steel hatchet, drawn the handle, and with much
pains hafted it as an adze. I believe, as pointed out in a paper
printed in volume ix of the *Transactions of the N. S. Institute
of Science,* that we have in this province, as indicated above,
remains of a previous settlement by the Eskimo, and we must
with great caution speak of the stone implements of Nova Scotia
as Micmac.* In subsequent remarks, I will speak generally
of these implements, without attempting to distinguish between
those that may be truly Micmac in origin and those that may
be Eskimo. When I use the expression "common" in regard
to a certain form of implement, the expression is a relative
one in comparison with other aboriginal relics in this province,
and does not compare with the abundance of an implement
that might be termed common in a region where such relics are
far more numerous than here. It may be mentioned that so
far no implements that can be fairly called palæolithic have been
found in Nova Scotia, nor under circumstances that would
lead to their being so considered, and we must regard all
remains here as belonging to the neolithic age.

Arrow-heads are common and are nearly always of some
siliceous stone, mostly jaspideous, such as are found *in situ* in
the western parts of the province. They are of various sizes,
from less than an inch to the larger size which grades into the
so-called spear-head. They are of various forms: leaf-shaped,
notched, and stemmed. Some of these were no doubt actually
hafted and used as knives, particularly the larger leaf-shaped
ones. The site of an arrow-maker's workplace was discovered

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*See also Patterson, *Trans. Inst. Nat. Sc.*, vii, pp. 236-237.

a number of years ago at Bachman's Beach, near Lunenburg, and furnished a large number of specimens, including many chips and some heads not completed.

Of so-called *spear-heads* there are a much lesser number. Many of these were probably cutting implements or knives, as also some of the larger arrow-heads as before mentioned. Otherwise we fail to find the aborigine's stone knife, an implement that must have been common among them. Lescarbot makes no mention whatever of spears as in use in his day, although he describes their various other weapons (see previous pages). Denys, however, frequently mentions spears, headed with bone, as in use among the tribe, and also knives of bone. There have been found at Milton, Queen's County, a few long, polished slate implements, like poniard blades, one of which is 18 inches long and tapers regularly from 1.75 inch in width at the base to about .75 of an inch near the end, where it suddenly diminishes to a point. These could only have been ceremonial implements, such as the long delicate blades found in California, as their fragile nature would forbid any rough usage, such as that of war or sport.

While referring to the cutting implements of our Indians, it may be mentioned that the Micmacs at the present time and for as long as is in the memory of man, have exclusively used in woodworking, etc., a peculiarly-shaped knife (somewhat like that of a farrier), the blade of which is made by themselves from an old file, which they invariably use by drawing towards them. This strong preference for a drawing cut, instead of one directed away from the body as is the manner among Europeans, is without doubt of pre-historic origin, and is worthy of attention from anthropologists, as possibly having some connection with the similar preference for a drawing cut which is evidenced by some east Asiatic peoples. Reference will be also made to the prevalence here of draw-cut stone implements such as the adze, which I think indicates the former presence or influence of the Eskimo.

Adzes or "celts" are common, in fact with the exception of arrow-heads are the most abundant relics found. They are nearly all unmistakable adzes, with one side more or less flattened, and intended for a drawing-cut with the edge at a right angle to the haft. It is this marked prevalence of the adze that leads me to believe that these are largely the remains of an earlier occupancy of the country by Eskimo, the more typical Algonquian (Micmac) implement, the true grooved-axe, being very rare, and indicating a briefer occupancy by the latter tribe. Fuller particulars on this subject will be found in my paper, "Relics of the Stone Age in Nova Scotia," *Trans. N. S. Inst. Sc.,* vol. ix, pp. 36 *et seq.* These adzes are mostly more or less slender, although some are only about twice as long as broad. Nearly all are neatly and systematically formed from pecked and polished stone, such as quartzite, hard slate, etc., while one is of sandstone. A few are very roughly chipped into form, somewhat palæolithic in appearance, but may not have been completed.

I can find nothing that I would care to strictly designate a *chisel*.

Gouges are common, and are formed of similar material to that of the adzes, into which they somewhat intergrade. In some the groove is almost indistinguishable, and is confined to the vicinity of the cutting edge. Others have a well defined, deep groove extending about half the length, and others have a deep groove extending the whole length. The last seems to be a distinct implement from the others. Gouges are somewhat adze-like in side outline, and those with the groove extending half the length were undoubtedly hafted as adzes.

Grooved axes, as before mentioned, are rare in Nova Scotia. The Patterson collection contains only one specimen, while there are ten in the Provincial Museum (namely, two in the general collection, six in the DesBrisay collection, and two in the Fairbanks collection). One of those in the Museum is

double-grooved, and in this respect it is unique in this province. They are well formed from water-worn oval quartzite boulders with the groove and edge "pecked" into shape. The grooves completely encircle the implement.

Hammer- (*or club-*) *heads* are very rare. I have only seem two—one in the DesBrisay collection in the Provincial Museum and one in my own possession. The latter was dug up at Dartmouth, and is neatly formed from an egg-shaped quartzite boulder, 3.50 inches long, entirely encircled by a pecked groove for the purpose of lashing it to a handle. It was no doubt used as a weapon, and the present Indians have a tradition that such hammers on occasions were thrown at an enemy and I have heard them say that a man could be thus struck with them when he was sheltered by a tree, attributing this to some magic properties of the weapon. The experiment might be tried to see if when hurled they can be made to take a laterally curved trajectory, somewhat after the manner of a boomerang, although the symmetry of the hammer would make it seemingly impossible for it to do so.

Pendants or "sinkers" are rare. Two are in the Patterson collection, and nine are in the Provincial Museum (namely, seven in the DesBrisay collection and two in the Fairbanks collection). Dr. J. B. Gilpin figured one, and I have seen one belonging to the late W. C. Silver, of Halifax; a total of thirteen. All are carefully fashioned, of graceful outline, and while of the same general appearance, differ very much in detail of form. None have a hole for suspension, but they have a little knob on top. I do not believe they were used as sinkers, as they are far more elaborately wrought than would be necessary for such a purpose. More likely they were used in some way as charm-stones, or in some religious ceremony, and I think I have heard Chief Noel affirm that they were employed as a charm to bring fish to a fishing place, while there are Indians who believe they were used as "sling-shots." Perhaps

the best explanation, to my mind, of their use, was given me by an Indian who says that years ago a very old Micmac woman informed him that they were employed as whorls in spinning thread from beaver's fur to make cloth in which to encircle a couple at the conclusion of the marriage ceremony in pre-historic times.

Pipes are somewhat rare. Sixteen are in the collections referred to; namely, three complete ones and one incomplete 'n the Patterson collection; and twelve in the Provincial Museum (seven complete ones, one of which is probably of European manufacture for barter, and one in process of manufacture, in the general collection; and three complete and one under construction in the DesBrisay collection). Besides these there is an old pewter pipe such as was used in barter by the early traders.

What is considered as the typical Micmac pipe has a pear- or barrel-shaped bowl upon a keel-shaped base, the latter with one or more holes to suspend it about the neck to prevent loss. A remarkable example in the Provincial Museum has bowl and stem in one piece, the former with a boldly executed carving of a lizard with a tail lying along the lower surface of the stem. The whole pipe is about seven inches long, and it is formed of a light grey pipestone, finely polished. It was discovered near Upper Rawdon in 1870 with some iron implements, etc. In this part of the Dominion it is unique, and is doubtless not the work of Micmacs, but must have been secured by trade or conquest.* A pipe almost identical in form has been found in Pennsylvania (Dr. Rau) and a similar one in Ontario (D. Boyle). Another remarkable pipe was found at Musquodoboit, Halifax County, and is of the typical mound-builder's form, with flattened base, and like the preceding one must have been

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*I cannot agree with Dr. Ganong (Denys, p. 424, note) that this may be of Micmac manufacture. Denys (p. 424) mentions stone pipes with bowl and stem in one piece; and probably one from LaHave, N. S., in the DesBrisay collection, is such a one as the old writer refers to.

brought into this country as it is entirely un-Micmac in character. More-modern Micmac stone pipes, formed with steel tools, are ornamented with incised circles and lines, a style of ornamentation still prevalent in Micmac work of various kinds.

A few *pierced tablets* (flat, polished slate stones, with one or two small round holes in them) are in the Provincial Museum, and the Patterson collection contains one. They have been supposed by some to have been used in shaping bowstrings, but their use here, as elsewhere, is obscure.

Two snake-shaped *rings* of white limestone, probably artificial, are in the Provincial Museum, and if of man's workmanship, must have been charm-stones, possibly connected with snake-worship.

Portions of two long *stone tubes* (just such as have been described by Schoolcraft from the Ohio mounds) were found many years ago at Dartmouth and are now in our Museum. They are of similar stone to that of the lizard pipe previously described. They show very great skill in manufacture. One end is entirely open, while the other has but a small hole in it. Various theories have been advanced as to the use of such implements were found in America. The Micmac chief, John Noel, told me that tradition says they were used, in the manner of a syringe, for administering a medicated solution per rectum. This is at least a novel explanation, and is noted for what it may be worth.

Some pieces of worked *copper* have been found, consisting of hammered nuggets of native copper, rough knife-shaped implements, and piercers; all made from the native copper of the trap of the Bay of Fundy.

Bone implements are uncommon, but there are several specimens in the Provincial Museum and the Patterson collection, namely, piercers, fish-spears, ivory harpoon-points (similar to those used by the Eskimo) and pieces of walrus ivory.

Two strings of *shell wampum* are in the Provincial Museum, and were doubtless brought into the province by barter with the Indians of New England, as Lescarbot mentions.

A considerable quantity of *pottery* has been found at various places throughout the province, some being ornamented by impressions of twisted cords, oblique dashes, crescent-shaped impressions, zig-zag rows of small square dots, etc. Some of the pots at least have been obtusely pointed on the bottom.

Of *relics of European manufacture* obtained by the Indians by barter, we find iron or steel axes and tomahawks, spear-heads, knives, kettles, metal pipes, glass beads, etc.

Kitchen-middens.—Kitchen-middens have been met with in various parts of the Nova Scotian coast and on rivers and lakes, such as would be favorite camping grounds in the past. They furnish shells, bones, implements, pottery, and various camp refuse. Gossip described the opening of some (*Trans. N. S. Inst. Nat. Sc.,* i, pt. 2, 94-99), and Patterson also refers to a number of locations (ib., vii, 237 *et seq.*), but none seem to have been opened and examined with the thorough scientific care which is now usually devoted elsewhere to such investigations.

Mounds.—Nothing resembling mounds has yet been discovered in the province.

Petroglyphs.—At Fairy Lake or Kojimkoojik ("swelled parts)", on the upper waters of the Liverpool River, are many very interesting incised drawings on slate, doubtless the work of Indians, in some parts with superimposed drawings of much later date, probably the work of woodsmen. Similar drawings are found at George's Lake (near Kojimkoojik) and on Port Medway River, all in Queen's county. 331 sheets of tracings of the oldest of these drawings, made by the late Geo. Creed in 1887 and 1888, are preserved in the Provincial Museum. (See Creed's unpublished paper mentioned in the bibliography; also *Report of Provincial Museum for* 1910, as well as *10th Ann. Report of Bureau of Ethnology for* 1888-89, Wash., pp. 37-42).

BIBLIOGRAPHY.

(The following is a fairly complete list of works treating of the Micmac tribe. Information on the subject may also be obtained in the Reports of the Indian Commissioner in the earlier volumes of the Journals of the N. S. Assembly, and also in the Reports of the Department of Indian Affairs, Ottawa, since 1867.)

1598. **Cartier (Jacques).**—Discours du Voyage aux Terres neufves de Canada. Paris, 1598.— Cartier's first voyage was made in 1534, but he makes but a mere mention of our Indians.

1609. **Lescarbot (Marc).**—Nova Francia. . Lond., 1609.— Also later editions, and recently republished by the Champlain Society, Toronto, 1907, to be in three volumes. Also in the original French, Paris, 1609. Contains interesting account of the Micmacs of that early period. Lescarbot went to Port Royal (Annapolis) in July, 1606.

1616. **Biard (Père Pierre).**—Relation de la Nouvelle France. Lyons, 1616.— See Thwaite's edition, Jesuit Relations, vols. iii and iv.

1632. **Champlain (Samuel de).**—Les Voyages de la Nouvelle France occidentale, 1603-1629. Paris, 1632.— Also subsequent editions. Gives short account of hunting and burial customs.

1672. **Denys ([Nicholas]).**—Description geographique et historique des Costes de l'Amerique septentrionale. Avec l'Histoire naturelle du Pais. 2 vols. Paris, 1672.— The second vol. ('Histoire naturelle des peuples,' etc.), chap. 23-24, treats very fully of the Indians (Micmacs). See the very fine annotated translation by Dr. W. F. Ganong, with original text, published by the Champlain Society, Toronto, 1908. This work contains very much that is of the greatest interest to those studying the early customs, etc., of the Micmacs of Nova Scotia.

1691. **Le Clercq (Père Christien).**—Novelle Relation de la Gaspesie. Paris, 1691. 572 pp.— Contains much concerning the Micmacs of Gaspe Bay, Quebec Province, whom he calls Gaspesiens. Le Clercq invented the hieroglyphs, still in use among the Micmacs, some of whom write and read them, and in which Kauder printed his catechism at Vienna; see 1866.

1758. [**Maillard** (Abbé **Anthony S.**)].—Account of the Customs and Manners of the Micmakis and Maricheets, Savage Nations, now dependent on the Government of Cape Breton. By a French Abbott. Lond., 1758. 138 pp.

1815. **Bromley (Walter).**—Two addresses on the Deplorable State of the Indians; one delivered August 3, 1813, the other March 8, 1814, at Halifax. (Published for the benefit of the Indians). London, 1815. 71 pp.

1820. **Bromley (Walter).**—An appeal to the virtue and good sense of the inhabitants of Great Britain, in behalf of the Indians of North America. Halifax, 1820. 57 pp.

1823-25. [**Bromley (Walter)**].—A General Description of Nova Scotia. [Anon.] Halifax, 1823. New edition: Halifax, 1825. 200 pp.— Chapter v. (pp. 44-58) deals with "The Indians (two tribes), attacks on Canso, treaty, customs, manners, civilization, and specimens of their language." Bromley, who was on the half-pay of the 23rd Regiment of Foot, established the Acadian School at Halifax on 31st July, 1813, and took a deep interest in the Micmacs, their customs, language, etc., he being apparently the first Englishman to do so to any extent.

1827. **West (John).**—Journal of a Mission to the Indians of the British Provinces of New Brunswick and Nova Scotia, and the Mohawks on Grand River, Upper Canada. Lond., 1827.

1829. **Haliburton (Judge Thomas Chandler).**—Historical and Statistical Account of Nova Scotia. 2 vols. Halifax, 1829.— Contains miscellaneous historical references to Micmacs.

1836. **Bromley (Walter).**—Vocabulary of the Micmacs. In Gallatin (A.), Synopsis of Indian Tribes, in Am. Ant. Soc. Trans., vol. ii, pp. 305-367. Cambridge, Mass., 1836.

1850. **Rand (Rev. Silas Tertius).**—A Short Statement of Facts relating to the History, Manners, Customs, Language, and Literature of the Micmac Tribe of Indians in Nova Scotia and P. E. Island. Halifax, N. S., 1850. 40 pp.— This is a most valuable account of our modern Micmacs, written by one whose knowledge of them was very intimate. See also 1894.

1850. [**Rand (Rev. Silas Tertius)**].—The History of Poor Sarah; a pious Indian woman. In Micmac. [Halifax (?), 1850.]. 12 pp.

1853. [**Rand (Rev. Silas Tertius)**].—The Gospel according to St. Matthew in the Micmac Language. Charlottetown, 1853. 118 pp.— Also as Pela Kesagunoodumumkawa tan tula Uksakumamenos Westowoolkw Sasoogoole Clistawit ooten- ink; Megumoweesimk; Chebooktook [Halifax], 1871; sometimes with almost the entire New Testament.

Rand subsequently published, anonymously, Micmac transla- tions of the Bible as follows, and later editions of the same, which will be found fully set forth in Pilling's Biblio- graphy:—St. John (Halifax, 1854, 95 pp.); St. Luke (Bath, 1856, 148 pp.); Genesis (Bath, 1857, 213 pp.); Psalms (Bath, 1859, 282 pp.); Acts (Bath, 1863, 140 pp.); Exodus (Halifax, 1870, 166 pp.); St. Mark (Halifax, 1874, [39 pp.]); Epistles and Revelation (Halifax, 1874, [216 pp.]). Also, with his name, The Gospels of St. Matthew, Mark, and Luke, with the Epistles and Revelation, translated from the Greek into Micmac; Halifax, 1875; 126+[39]+[68]+[216] pp.

1854. **Rand (Rev. Silas Tertius)**.—Ferst Reding Buk in Mikmak. London, 1854. 40 pp.— For second edition, see 1875.

1861. [**Shea (John Gilmary)**].—Micmac or Recollect Hieroglyphics. Historical Magazine, 1st series, vol. v, pp. 289-292; New York and London, 1861.— A general account of the inven- tion of these symbols by LeClercq, and their use, also the Lord's Prayer in hieroglyphs.

1864. **Ambrose (Rev. John, M. A.)**.—Some account of the Petral ... with a few observations on a beach-mound or kitchen- midden, near French Village. Trans. N. S. Institute of Natural Science, i, pt. 2, pp. 34-44. Read 4 Jan. 1864.— Kitchen-middens described on pages 42-43.

1864. **G[ossip] (W[illiam])**.—On the occurrence of the Kjockken- moedding, on the shores of Nova Scotia [at French Village and Cole Harbour, Halifax Co.]. Trans. N. S. Inst. Nat. Sc., i, pt. 2, pp. 94-99.

1864. **Maillard (Abbé [Anthony S.])**.—Grammar of the Mikmaque Language of Nova Scotia, from the manuscripts of the Abbé Maillard. New York, 1864. 101 pp.— (Vol. 9 of Shea's Library of American Linguistics.)

1865. **Murdoch (Beamish).**—History of Nova Scotia. 3 vols. Halifax, 1865-7.— Contains miscellaneous historical references to the Micmacs.

1865. **Uniacke (Rev. Richard J[ohn]).**—Sketches of Cape Breton, originally addressed as letters to Archbishop Whately. Preface dated, Sydney, C. B., 12 Sept., 1865, but originally written about 1862. Unpublished (?) manuscript in files of N. S. Historical Society.—Chapter 8 (20 pp.) is on the "Native Indians."

1866. **[Kauder (Rev. Christian) of Tracadie, N. S.].**—Buch des gut enthaltend den Katechismus, Betrachtung, Gesang. Wien, [Vienna], 1866. 146+110+210 pp.— Catechism, meditations and hymns, printed in the Micmac hieroglyphics invented by Father Christien Leclercq, which had previously only been used in manuscripts. Each of the parts of this book were also published separately; same place and date.

1868. **Dawson ([Sir] John William).**—Acadian Geology. 2nd ed. London, 1868.— Pp. 41-46 of chapter 4, contains remarks on prehistoric man in Nova Scotia; and Micmac heads are figured opp. p. 41, and a few stone implements on p. 43. Appendix A, pp. 673-675, is on the Micmac language and superstitions.

1869. **Akins (Thomas B[eamish], D. C. L.).**—Selections from Public Documents of Nova Scotia. Halifax, 1869.— Miscellaneous historical references to Micmacs, text of treaties, etc.

1870. **DesBrisay (Mather B[yles], M. P. P.).**—History of County of Lunenburg. [1st ed.] Halifax, 1870.— The aborigines are dealt with on pp. 150-159. See also enlarged 2nd ed., 1895.

1871. **[Rand (Rev. Silas Tertius)].**—[Terms of Relationship of the Micmacs, and Etchemins or Malisetes, collected by Rev. S. T. Rand, missionary, Hantsport, N. S.] In Morgan (Lewis Henry), Systems of Consanguinity and Affinity of the Human Family, (Smithsonian Contributions to Knowledge, vol. 17, no. 218), pp. 293-382, lines 59-60; Washington, 1871.

1873. **Gilpin (J[ohn] Bernard, M. D.).**—On the Stone Age of Nova Scotia. Trans. N. S. Inst. Nat. Sc., iii, pp. 220-231, with plate illustrating 10 specimens. Read 10th Feb., 1873.

1873.   Rand (Rev. Silas Tertius).—Short Account of the Lord's Work among the Micmac Indians. Halifax, 1873. 32 pp.

1873.   Campbell (Duncan).—Nova Scotia. Montreal, 1873.— Pp. 17-26 treats of the Micmacs, the information having been evidently derived from Rand's Short Statement of Facts.

1875.   [Rand (Rev. Silas Tertius, D. D.)].—A First Reading Book in the Micmac Language. Halifax, 1875. iv, 5-108 pp.— This is a most necessary book for anyone studying the Micmac language. See also 1854.

1877.   Gilpin (J[ohn] Bernard, M. D.).—Indians of Nova Scotia. Trans. N. S. Inst. Nat. Sc., iv, pp. 260-281. Read 12 March, 1877.— Treats, in a most interesting manner, of the Micmacs in historic time.

1877.   Patterson (Rev. George, D. D.).—History of County of Pictou, N. S. Montreal, 1877.— Pp. 26-37 is devoted to an account of the Micmacs.

1878.   Dawson (Sir John William).—Supplement to second edition of Acadian Geology. London, 1878.— Additional matter on Micmac remains is given on pp. 18-19, with figure of a bone harpoon-head on p. 19.

1883.   Patterson (Rev. George, D. D.).—Antiquities of Nova Scotia. Annual Report Smithsonian Inst. for 1881. Wash., 1883, pp. 673-677.

1884.   Leland (Charles G[odfrey]).—Algonquin Legends. Bost., 1884. 377 pp., illus.— Founded chiefly on the legends collected by Rand. See 1894.

1885.   Rand (Rev. Silas Tertius).—The Micmac Language. In Canadian Science Monthly, Nos. 10-11, pp. 142-146; Kentville, N. S., Oct.-Nov., 1885.— A general discussion, including some polysynthetic words.

1888.   Rand (Rev. Silas Tertius, D. D., LL. D.).—Dictionary of the Language of the Micmac Indians. Halifax, 1888. viii, 286 pp.— English-Micmac part only published, but the Micmac-English section is in manuscript.

1888.   Rand (Rev. Silas Tertius).—The Micmac Indians. Our Forest Children, vol. ii, no. 4, pp. 10-12; Shingwauk Home, Sault Ste. Marie, Ont., 1888.— Grammatic remarks, p. 11; vocabulary of about 80 words and sentences, Micmac and English, pp. 11-12; etc.

1888. **Creed (George).**—Pictographs at Fairy Lake, Queens Co., N. S. Read before Nova Scotia Historical Society, 13th November, 1888, but not published entire. A very full summary of it appears in the Morning Chronicle (newspaper), Halifax, of 14th November, 1888.— 331 sheets of the copies of the petroglyphs made by Creed in 1887 and 1888 to illustrate this paper, are now preserved in the Provincial Museum at Halifax.

1888. **Brown (George Stayley).**—Yarmouth, N. S. Boston, 1888.— Chapter 7 (pp. 86-101) treats of the Micmacs.

1889. **Patterson (Rev. George, D. D.).**—The Stone Age in Nova Scotia, as illustrated by a collection of relics presented to Dalhousie College. Trans. N. S. Inst. Nat. Sc., vii, pp. 231-252. Read 11 Feb., 1889.

1889. **Piers (Harry).**—Aboriginal Remains of Nova Scotia, illustrated by the Provincial Museum Collections. Trans. N. S. Inst. Nat. Sc., vii, pp. 276-290, with 1 plate illustrating 6 specimens. Read 13 May, 1889.

1890. **Rand (Rev. Silas Tertius).**—Legends of the Micmac Indians. American Antiquarian, vol. xii, p. 3; Chicago, 1890.

1891. **Pilling (James Constantine).**—Bibliography of the Algonquian Languages. Washington, Bureau of Ethnology, 1891. 614 pp.— An exhaustive work on the subject, giving full titles and biographical sketches of authors of works dealing with the language of the Micmacs, etc.

1893. **Mallary (Col. Garrick).**—Picture-writing of the American Indians. In 10th Annual Report of Bureau of Ethnology, 1888-9; Washington, 1893—Describes petroglyphs on Fairy rocks, Queens Co., N. S., on pp. 37-42, and figures Nos. 1, 2, 549, 550, 654 to 658, 717, 718, 739 to 741, 1254, 1255, and 1262, illustrate Nova Scotian examples.

1894. **Rand (Rev. Silas Tertius, D. D., D.C.L., LL. D.).**—Legends of the Micmacs. New York & Lond., 1894. xlvi, 452 pp.— Pp. xvii-xxix give bibliography of Rand's works and biblical translations in Micmac; and on pp. xxx-xlvi is an account of the manners, customs, language, and literature of the Micmacs from Rand's pamphlet, "A Short Statement of Facts" (1850).

1895. **Piers (Harry).**—Relics of the Stone Age in Nova Scotia. Trans. N. S. Inst. Nat. Sc., ix, pp. 26-58, with 3 plates illustrating 98 specimens, nearly all in the Fairbanks collection. Read 13 May, 1895.

1895. **DesBrisay (Judge Mather Byles).**—History of the County of Lunenburg. 2nd ed. Toronto, 1895.—Chapter xxx (pp. 341-351) is devoted to the aborigines, murders and scalpings by them, burial places, and interesting incidents.

1896. **Hagar (Stansbury).**—Magic and Medicine of the Micmacs. Journal of Am. Folk-Lore, vol. ix, p. 170; Boston, 1896.

1897. **Hagar (Stansbury).**—Weather and the Seasons in Micmac Mythology. Journal of Am. Folk-Lore, vol. x, p. 101; Boston, 1897.

1897. **Calnek (W[illiam] A.) and Savary (Judge A W.).**—History of County of Annapolis. Toronto, 1897.—Contains a few references to the Micmacs.

1899. **McLeod (Robert R[andall]).**—In the Acadian Land: Nature Studies. Boston, 1899.— The Micmac Indians are described on pp. 140-155.

1900. **Gatschet (A[lbert] S[amuel]).**—Micmac Fans and Games. Bulletin of Free Museum of Science and Arts, Department of Archæology and Palæontology, Univ. of Penn., vol. ii, No. 3, May, 1900, pp. 1-5.— Describes fans, and the game "altesta-an."

1900. **Wilson (Isaiah W.)**—Geography and History of the County of Digby, N. S. Halifax, 1900.— Pp. 21-26 treats briefly of the Micmacs.

1903. **McLeod (Robert R[andall]).**—Markland or Nova Scotia. [Chicago?], 1903.—Chapter xi, pp. 166-175 is on the Indians of Nova Scotia.

1907. **Hodge (Frederick Webb).**—Handbook of American Indians. 2 vols. Bulletin Bur. of Am. Eth., 30. Wash., 1907. Article 'Micmac,' vol. 1, pp. 858-859 (by Jas. Mooney & Cyrus Thomas).

1908. **Hewitt (Harry W.).**—Customs of the Micmac Indians. Unpublished manuscript of 33 pp., read before N. S. Historical Society, 21 April, 1908, and preserved in files of that Society.

1910. **Eaton (Rev. Arthur Wentworth Hamilton, D. C. L.).**—History of King's County, N. S. Salem, Mass., 1910.— Chapter 2, pp. 10-22, treats of the Micmacs.

1910. **Piers (Harry).**—[Anthropological Accessions to Provincial Museum.] Report on Prov. Museum for 1910, in Report of Department of Mines of N. S., for 1910, pp. 205-210.— Describes Creed's copies of petroglyphs on Fairy rocks, etc., recent costumes, work and implements of Micmacs. Earlier reports contain short items on similar subjects.

1911. **Prest (Walter H.).**—Suggestion for Anthropological Work in Nova Scotia. Read before N. S. Inst. Sc., 13 Feb. 1911, and to be published in its Trans., vol. xiii, pp. 35-39.

1911. **Prest (Walter Henry).**—Report on Cave Examination in Hants Co., N. S. Trans. N. S. Inst. Sc., vol. xiii, pp. 87-94.—Negative results from a search for prehistoric remains in three caves selected for investigation.

1911. **Piers (Harry).**—[Anthropological Accessions to Provincial Museum.] Report on Provincial Museum, for 1911, in Report of Department of Mines of N. S., for 1911, pp. 239-241.— Describes some implements and natural forms of rock which have been mistaken for the work of Indians, &c.

The student is also referred to the following volumes of manuscript documents (among others) preserved in the Public Records of Nova Scotia:—

Vols. 430-431. Papers relating to Indians in Nova Scotia, from 1751 to 1866.

Vol. 432. Journal kept by Hon. Joseph Howe while Commissioner of Indian Affairs (appointed 1842), containing also plans of Indian reserved lands.

The Electrical Resistance and Temperature Coefficient of Ice.—By J. H. L. Johnstone, B. Sc., Dalhousie University, Halifax, N. S.*

The following investigation was first begun in January, 1911, with the object of determining the resistence of ice.

A great many difficulties were subsequently met with, which resulted, as will be seen, in a modification of the original methods. of experiment; and several other problems appeared, closely connected with the one treated of in this paper, the chief one of which is the effect of polarization, and its nature as related to ice. The latter problem is to be investigated fully at a later time.

Dr. H. L. Bronson, when working in the Physical laboratory at McGill University, noticed the peculiarities connected with this problem and as a result this work was undertaken, with his guidance, by the writer.

The only measurements of the resistance of ice, that could be found after a diligent search, were obtained from a paper by Ayrton and Perry.[1] As these measurements appear to be the only ones published, a brief summary, together with the results of their work, is given here.

Aryton and Perry measured the resistance of ice as follows:
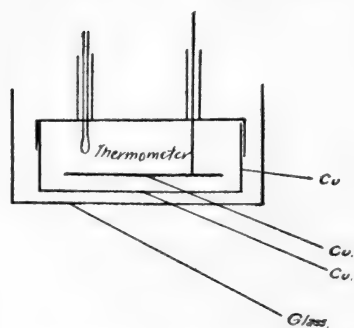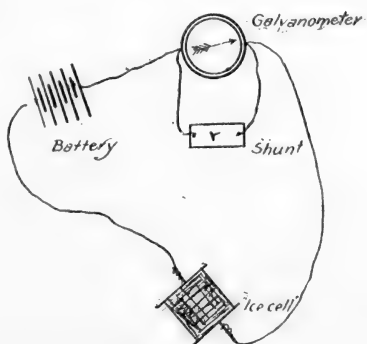
FIG. 1.   FIG. 2.

Ice was frozen from distilled water in a copper vessel, like that shown in Fig. 1. Connections were then made as shown in Fig. 2, the current passing through the ice being measured by a galvanometer. Knowing the E. M. F. of the cells in the

TABLE I.

AYRTON AND PERRY'S
VALUES
FOR THE RESISTIVITY OF ICE AND H_2O.

TEMPERATURE °C.	RESISTIVITY.
-12.4	22.4×10^8
-6.2	10.23×10^8
-5.02	9.486×10^8
-3.5	6.42×10^8
-3.0	5.693×10^8
-2.46	4.844×10^8
-1.50	3.876×10^8
-0.2	2.84×10^8
$+0.75$	1.188×10^8
$+2.2$	2.48×10^7
$+4.0$	9.10×10^6
$+7.75$	5.4×10^5
$+11.02$	3.4×10^5

Resistance in ohms. ("BA").

TABLE II.

SPECIMEN.
AYRTON AND PERRY'S
RESULTS.

VOLTAGE	TIME	GAL. DEFLECTION
2.61	0	30.1
4.25	1	39.5
	3	36.5
	$4\frac{1}{2}$	50.5
8.7	$5\frac{1}{2}$	49.1
17 4	$6\frac{1}{2}$	72.7
	$7\frac{1}{2}$	69.0
	$12\frac{1}{2}$	59.5
28.7	$13\frac{1}{2}$	76.5
	$17\frac{1}{2}$	67.2
Ice short	circuited for 4	minutes
87.	— great swing	off scale.
	$23\frac{1}{2}$	212
	$26\frac{1}{2}$	145
	83	66.2
	129	66.2
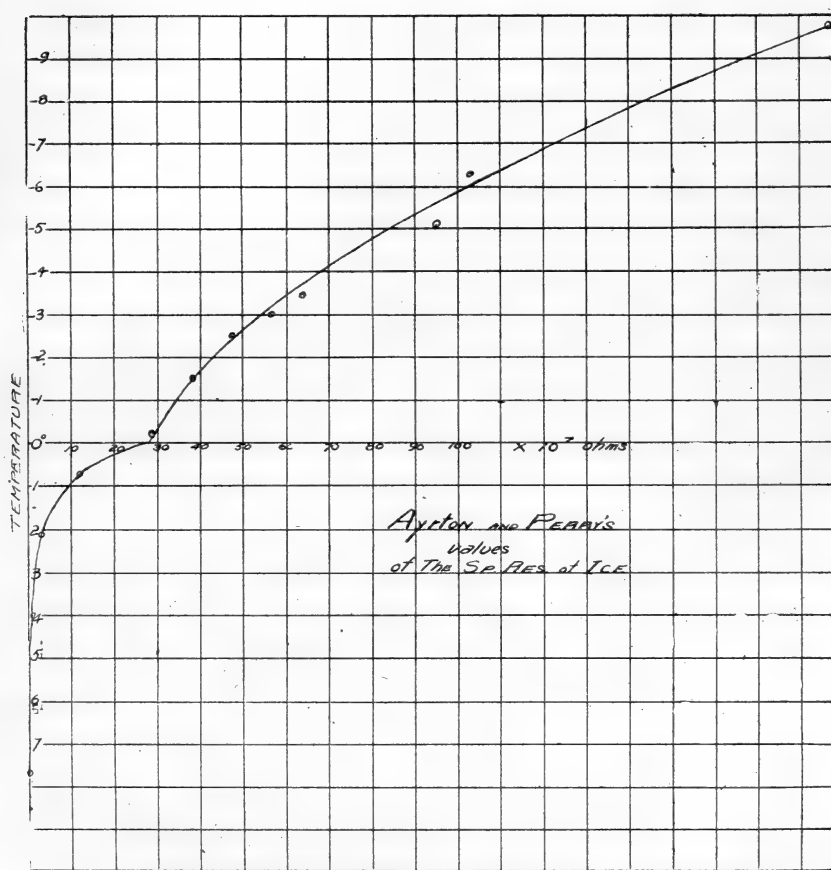
FIG. 3.

circuit, the resistance of the sample of ice was calculated from these data, and from this, the specific resistance of the ice. This was done for several temperatures.

A great difficulty was encountered in determining the actual value of the current passing through the ice. Ayrton and Perry were troubled greatly by polarization effects which, at that time, they were unable to determine the nature of. As they could not eliminate this effect, which will be shown to be

very considerable at times with the method of experimenting, their results do not appear to be very reliable.

The method just outlined was first used and investigated, with results similar to those obtained by Ayrton and Perry[1] and to those obtained by Dr. Bronson.[2]

A D'Arsonval galvanometer, manufactured by Leeds and Northrup, was used as a current measurer, its sensitivity and resistance being first determined.

The resistance was determined by several methods, the mean of these several values being taken and found equal to 1930 ohms, at $17°$C.

The sensitivity, or current which produces a deflection of one scale division was determined as follows:

The galvanometer was connected in a circuit as shown in Fig. 4.
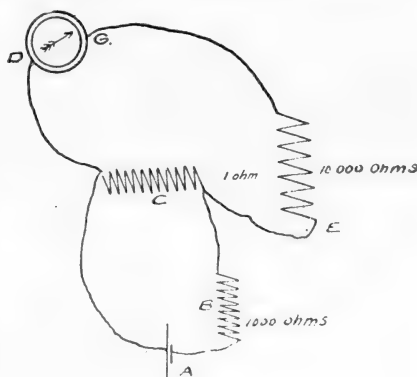
FIG. 4.

E is a 10,000 ohm resistance coil,
C is a standard one, (1), ohm coil,
A is a storage cell,
B is a 1000 ohm coil.

The E. M. F. of the storage cell, as determined by a Weston voltmeter was 2.00 volts, so the current passing through the galvanometer, $i = \dfrac{\dfrac{2}{1000}}{10000 + 1930}$ amperes.

1. Loc. cit.
2. Loc. cit.

It was observed that this current produced a deflection of 51 scale divisions. Therefore the current necessary to produce a deflection of one scale division, will be

$$\frac{\dfrac{2}{1000}}{(10001 + 1930)\,51} = 3.29 \times 10^{-9} \text{ amp.}$$

The specimen of ice was prepared as follows: Two brass electrodes,—circular discs, were made; a copper rod was soldered to one of them and a copper wire was soldered to the edge of the other one. A cylinder of ice, 3 cm. in height, was cut from ice, obtained from the Dartmouth Lakes. The electrodes were then frozen to this cylinder of ice by warming them slightly and then pressing them to the upper and lower surfaces of the ice. This conductivity cell, so to speak, was placed on a plate of parafine wax, and the whole thing was placed in a box, which was kept in the open air, shaded from the sun. Of course experiments could only be performed when the air was below the temperature of $0°C$, which was quite frequent at this period of the year. Several sets of readings are given below, together with a set of readings from Ayrton and Perry's papers.[1] The apparatus was connected up as in Fig. 2.

In the actual experiment, the current was made to pass through the ice for a considerable period of time, in some cases the circuit being unbroken for 48 hours.

When the current was suddenly reversed after flowing for quite a length of time in one direction, a very much greater deflection of the galvanometer was obtained than at first. This deflection decreased somewhat with time. Thus for instance, the deflection changes from 9 divisions, on one side of the zero, to 13 divisions on the other side when the current is reversed through the ice. This is an increase of 40% of the current, which passed through the ice in the initial case. If this is all due to

1. Loc. cit.

TABLE III.

JAN. 24, 25, 26, 1911.

Time	Temp.	Shunt	Voltage	Deflection	
				Right	Left
Jan. 24— 4.15		1 ohm.	20.9	9	13
4.45		"	"	6	15
4.50		"	40.7		27.5
8.0		"	20.9		3.5
10.00		40	1 "	102.0	106.0
" 25—10.45	−.5 °C	30	"	140*-65	
" " 12.00	"	"	"	73-23	83-37
" " 12.35	"	"	"	80.-29	
1.00	"	"	"	16	
2.00	+ 1°	"	"	175-158	
" 26—10.25	− 6°	"	"	17-15	19-15
10.30	"	"	20.1 cells	25	
10.45	"	"	40.7	102-23	
12.50	− 5°	"	10 cells	15-16$\frac{1}{2}$	

* The current took 10 seconds to fall from "140 - 65" in value.
† The current took 3 seconds to fall from 73-23 in value.
 In the 2nd column we have the temp. of air beside the ice, recorded.
 In the last column the deflections of the gal., and the deflections when the current is reversed, are given.

polarization, the phenomena we have here to treat of, are quite different from the so-called electrolytic polarization effects. Ayrton and Perry[1] noticed similar effects on reversal, and on short-circuiting their "cell," (see page 128). In one case, it will be seen that on short-circuiting their cell, the current increased about 175% of its original value. Similar results were consistently obtained by the writer.

1. Loc. cit.

As resistances calculated from such values of the current as the above would have little or no value, a method was then sought, whereby the effects just indicated could be eliminated.

A great deal of time was spent in attempting to find out the nature of this polarization and measure its value. The "Tuning Fork"[1] method of measuring electrolytic polarization was used first of all, with water as the electrolyte, and correct values were obtained. But when the ice cell was substituted for the water cell, this method would give no results on account, principally, of capacity effects. A "commutator" method was also tried with similar results.

By using Kohlrausch's method for measuring the resistance of electrolytes, the polarization effect would probably be eliminated. However, the maximum resistance that can be measured by this method is of the order of 10^6 ohms. As ice has a specific resistance of more than 10^8 ohms, this method is not practicable. It might be possible however, by taking thin sections of a block of ice, to measure its resistance by means of Nernst's conductivity apparatus.[2]

Now one of the methods of measuring the resistance of a solid conductor, is to determine the drop in potential between two sections of the substance, when a steady current is flowing through these sections. Knowing the values of i and e, the resistance can be calculated.

A method very similar to the above was adopted, and as will be shown, the effects of polarization, etc., will be eliminated as far as the measurement of the resistance is concerned.

The apparatus was set up, as shown in Fig. 5. B, is a "U" tube, 12 cm. in height, with a bore of about 2 cm. a and a_1 are glass tubes of $2\frac{1}{2}$ mm. bore, with platinum points sealed at the ends c and c_1. b and b_1 are glass tubes of 4 or 5 mm. bore, with

1   Watson, M. :—Text book of Physics, page 790.

2   Nernst. W. :—Zeitschr. f. phys. Chem., **14,** 622, (1894) ; also Maltby, M. E. : *ibid.* **18,** 133, (1895).
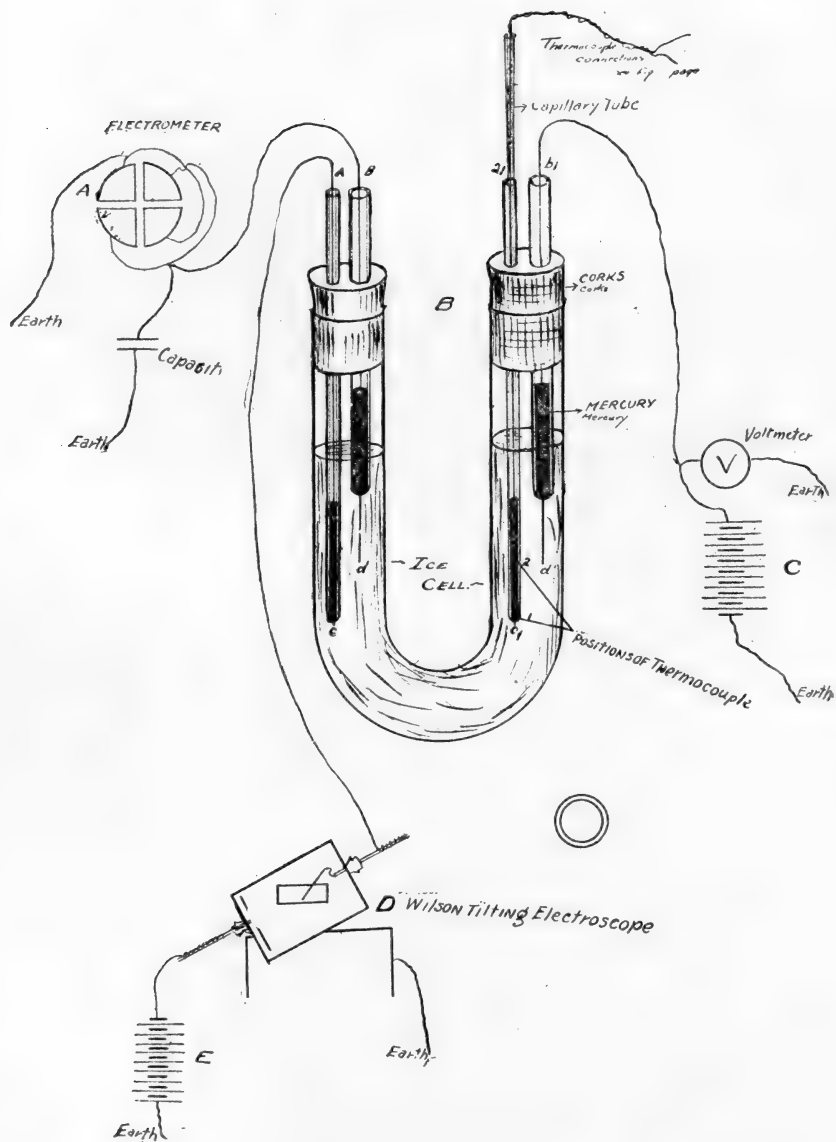
FIG. 5.

platinum wires, d and d_1 sealed in the end as shown in the figure. These four tubes are fitted carefully in corks, and then in the "U" tube as shown.

Now suppose we fill the tube with an electrolyte and pass a current through it, by way of the electrodes b and b_1. There will result a polarization at these electrodes and the value of the current will vary somewhat with the time. If this current is measured by a sensitive galvanometer and if the difference in potential of the two electrodes is measured by a voltmeter, a value of the resistance of the electrolyte could be calculated at any particular time; but this is a varying quantity, and not the true resistance of the electrolyte.

Now if two other electrodes a and a (see Fig. 5), are placed in the position shown in the figure, their ends c and c_1 being lower somewhat than the extremities of the platinum wires d and d_1, and then a current is passed through the electrolyte by way of the electrodes d and d_1; then if we measured the difference of potential between the points c and c_1, by some electrostatic instrument and knew the value of current, we could calculate the value of the resistance of the electrolyte between the points c and c_1, and the resistance so calculated would be constant in value and unaffected by polarization. This would be so, because when there is a variation in the current due to polarization or any other causes, there will be a proportional change in the potential difference between the two potential electrodes, so that the ratio of the potential difference to the current will be constant (with a const. temp.). Therefore the resistance determined in this way will have a constant value. Thus, polarization effects will be eliminated.

The current passing through the electrolyte, (which was ice in this case), was measured by a *Dolezalek* electrometer, A, (see Fig. 5). The potential of each potential electrode was measured by a *Wilson Tilting* electroscope, D, the plate of the electroscope being kept at a potential of 320 volts, from small storage cells. A calibration curve for this instrument, as it was used in these experiments is shown in Fig. 6. It

Wilson Electroscope. Calibration
April. 2, 1912.

I.	taken	at.	11 P.m	April 2.
II	"	"	11 P.m.	"
III	"	"	11 10 A.M.	" 3
IV	"	"	13.30 P.M.	" 3
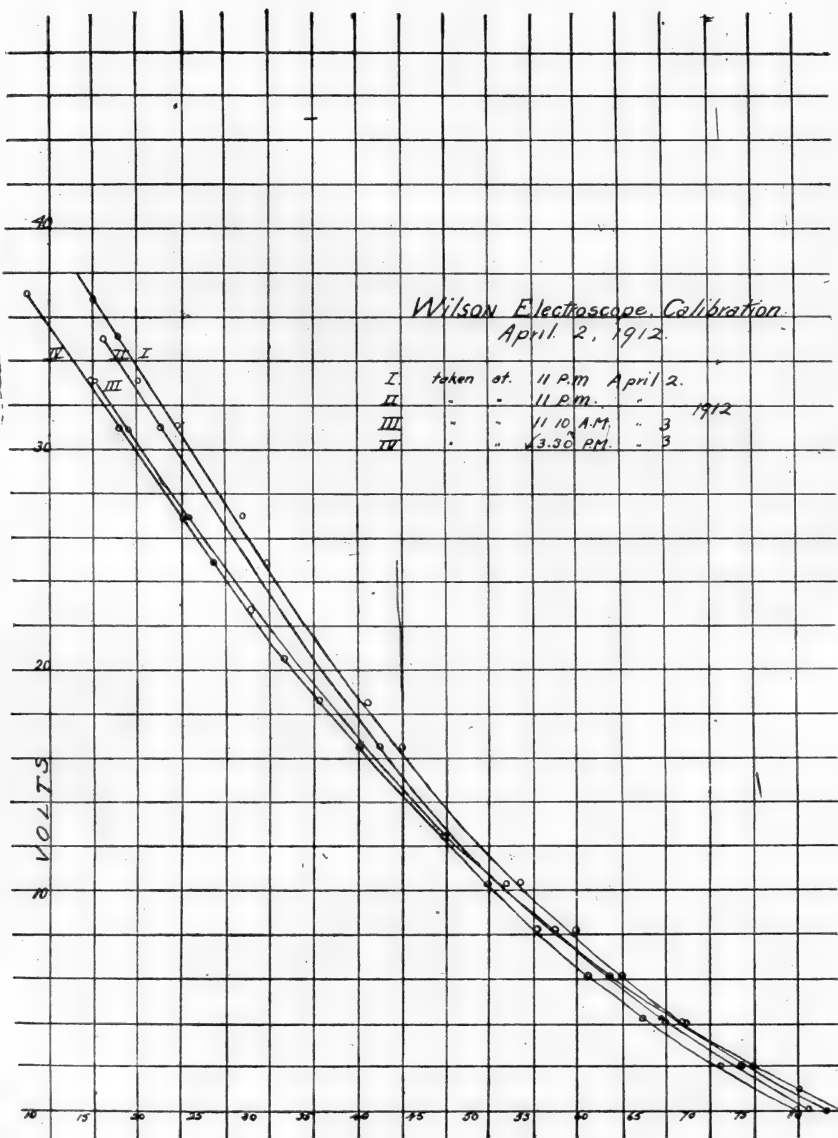
FIG. 6.

will be seen that this method of measuring high resistances of any kind, insulators for example, is very advantageous, for currents as small as 10^{-14} amperes, can be measured with ease by the *Dolezalek* electrometer, while the *Wilton Tilting* electroscope can be made very sensitive. For electrolytes with low resistances, the current could be measured by a galvanometer and the potential by the electrometer, since the latter as a current measure would be too sensitive for use in this case.

Preparation of the Ice.

Pure water was obtained with a resistivity of about 1×10^6 ohms.

After cleaning the "U" tube very carefully—first, in a solution of potassium bichromate and sulphuric acid, then in an alcohol-ether solution and then washing several times in distilled water, both hot and cold—the pure water was put in the tube, its resistance carefully determined and temperature noted. The specific resistance of a sample of this water was then determined by the *Kohlrausch* method, the temperatures being the same in the two cases. From these results the "cell constant" of the apparatus can be calculated.

The "U" tube was then placed inside a cylindrical glass vessel, about 15 cm. in diameter and 45 cm. in height. This was then placed in an earthenware-jar, which in turn was surrounded by an ice-salt mixture, contained in a bucket. The while apparatus was kept in a refrigerator.

A thermo-couple (Fig 7) consisting of a German-silver-iron junction, was used to measure the temperature of the ice, which was formed in the "U" tube. The junction was enclosed in a capillary tube, which could be slipped in and out of one of the electrode tubes, "a ", (Fig. 5). For a diagram of the connections of the thermo-couple see Fig. 7. A very careful calibration of this instrument was made over the range of
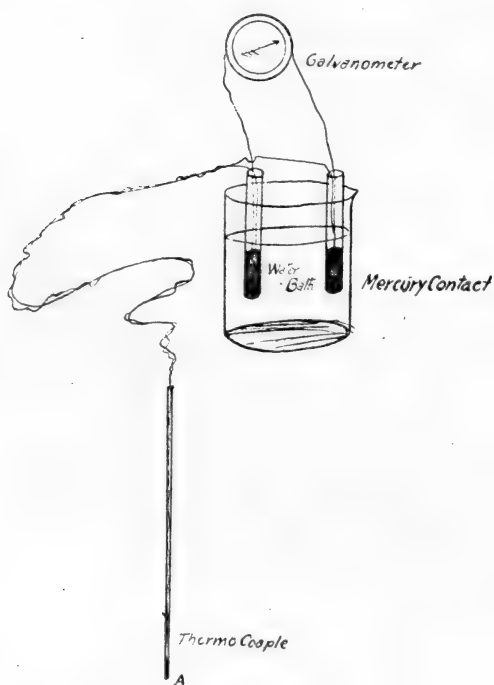
FIG. 7.

temperatures through which it was to be used in the experi-
ment, viz.—from 5° to —12°C.

It was found very difficult to freeze the water in the "U"
tube in the method described, without the tube being broken
by the expansion of the ice. To obviate this difficulty a piece
of rubber tubing, about .5 cm. in diameter and 15 cm. in length,
and very carefully cleaned by boiling, etc., was closed at one
end, by means of a glass stopper. The other end was also
closed with the exception of a small hole, the size of a pin-head.
This tubing was placed inside the "U" tube, care being
taken to prevent any quantity of water entering through the
opening in the one end. When the water expands on freezing,
it can be seen that a certain amount of freedom is allowed it,
by its being able to push in the lateral surface of the rubber

tubing, the air inside escaping through the pin-hole. It was found that the water could be frozen with ease in this way without the glass tube being broken.

The electrometer was then calibrated. In this experiment, the needle was changed to a potential of about 200 volts. The electroscope was then calibrated over the range at which it was to be used.[1]

To obtain a set of readings at different temperatures, the "U" tube was connected up with the electrometer and electroscope and source of current, (Fig. 5). In most of the experiments the current was obtained from 10 storage cells, which gave an E. M. F. of about 20 volts. The "U" tube was very carefully packed in the glass vessel with "felt" and so temperature changes were slow. The time, in seconds, for the electrometer needle to pass over 100 scale divisions, was recorded on a stop-watch. The temperature of the ice was then read from the thermo-couple. The potential difference of the two electrodes, c and c_1 (Fig. 5), was then determined from the electroscope readings at these points.

If $d \equiv$ the scale divisions passed over per second by the electrometer needle;

$D \equiv$ the number of divisions per volt, and $C \equiv$ the capacity of the system in microfarads, then the current, i, passing through the ice will be,

$$\frac{C\,d}{10^6\;D} \text{ amperes.}$$

If $V \equiv$ the potential difference of the two electrodes c and c_1, then R, the resistance of the electrolyte between c and c_1 will be,

$$\frac{V \times 10^6 \times D}{C\,d} \text{ ohms.}$$

If k denote the cell constant of the apparatus then the specific resistance of the ice will be,

$$\frac{V \times 10^6 \times D \times k}{C\,d} \text{ ohms.}$$

---

1. See Fig. 6.

In the following table column I gives the time at which the readings were taken; column II the readings of the electroscope, when the gold leaf was connected with each one of the potential electrodes, c and c_1; column III, the time taken for the electrometer needle to pass over 100 scale divisions; column IV, the temperature of the water bath in Fig. 7, the reading of the galanometer, and the calculated temperature of the ice; column V, the electromotive force used in the experiment; column VI, the capacity of the system; column VII, the calculated resistance and column VIII, the specific resistance of the ice. In the experiments performed, readings were taken as the temperature of the ice decreased to the minimum temperature for the particular salt and ice mixture in the outer vessel, and then as the temperature rose up to zero.

TABLE IV.

RESISTANCE OF ICE

CELL. CONSTANT = .315   April 2, 1912

Time	Electroscope I.	Electroscope II.	Electro- meter	Temperature I. Th Cp	Temperature II. Th, Cp	Cal.	Temp	E. M. F.	Cap.	Specific Res. (Ohms.)
4.10	15-83	61.1-83	1m. 24 s.	126	125	16.9	19.3⁰	41.2	0.05	3 86x10⁹
4 30	"	"	1m. 25 s.	127.8	125.5	17.0	19.7	"	"	3.90x10⁹
4.40	"	"	1m. 28 s.	128	125.5	16.9	19.9	"	"	4.04x10⁹
5.55	"	64.5-83	1m. 30 s	127	122	16.9	19.6	"	"	4,13x10⁹
7 40	14 5-80	62.0-80	1m. 17 s.	121½	"	16.3	18.6	"	"	3.56x10⁹
8 00	82-15	62 5-82	1m. 13 s.	120.2	118.8	16.4		"	"	3.47x10⁹
9.00	15-81.5	59.0-81	1m. 0 s.	117.0	117.0	16.4	17.2	"	"	2.69x10⁹
10 00	16-81 3	58-81-5	45 s	112.6	112.0	"	15 9	"	"	1.98x10⁹
10.04	81 5-16	"	46 "	111.1	111.0	"		"	"	
10 15	"	"	44 "	112.1	111.6	"	15.8	"	"	1.94x10⁹
10.20	81.3-16.5	58-81.3	45 "	111.0		16.4		"	"	
10.40	"	"	40 "	109.5	110.0	"		"	"	
11.00	14.5-81	55.5-81	22 "	95.0	93	"	10.8	"	"	
"	"	"	89 "	"	"	"	"	"	0.2	0 947x10⁹
11.10	"	"	90 "	94.5	"	"	10 6	"	"	0.958x10⁹
11.17	15 81.5	55-81.5	88 "	93.0	91.5	16.3	10.3	"	"	0.936x10⁹
11.40	"	"	88 "	90		"	9.4	"	"	0.852x10⁹
12.00	16-81.5	53.8-81.5	41½"	75	73.5	16.8	4.5	"	"	0.457x10⁹
12.15	"	"	39 "	72.5	72.0	16.75	3.85	"	"	0.430x10⁹
12.25	15-81.5	54.2-81.5	38½"	71.5	70.0	16.8	3.5	"	"	0.410x10⁹
A. 3.										
10.15	23-80 5	67 80.5	48 "	77.3	76.0	14.8	7.1	"	"	0 464x10⁹
10.25	"	"	" "	77.1	76.0	"		"	"	
11.10	20-82.5	64-82 5	79 "	62.1	61.0	15.2	2.3	"	1.00	0.169x10⁹
11.15	"	66-82.5	85 "	63.0	61.3	15.2	2.6	"	"	0.181x10⁹
11.33	"	"	36 "	77.5	77.0	15.3	6.8	"	0.20	0.390x10⁹
11.37	"	"	39 "	81.0	79.1	"	7.8	"	"	0,423x10⁹
11.47	21.6-82.6	62-82.6	21 "	56.8	55.6	15.4	0.6	"	1.00	0.0386x10⁹
11.55	"	"	19½"	55.0		"	0.1	"	"	0.0349x10⁹
12.00	"	"	19 "	"		"		"	"	
12.10	20.0-82.4	58-82.4	21 "	55.1	57.0	"	0⁰	"	"	0.0367x10⁹

It was found that the rubber tubing in the "U" tube affected the conductivity of the contents to quite an extent, and in this particular experiment the water was frozen without the presence of the rubber, and also in the succeeding experiments. However, the general shape of the temperature resistance curve was found to be the same in every experiment performed.

The water, which was put in the cell originally, had a specific resistance of about 1.4×10^6 ohms at $17.9°C$.

In the measurement of the temperature of the ice between the "potential" terminals, by the thermo-couple, it was found that there was a considerable temperature-gradient in the "U"

tube in the direction of its length, although the tube was enclosed in three separate vessels, in a refrigerator and closely packed with felt.   The junction of the thermo-couple was enclosed in a capillary-tube, (see Fig. 7), so that it could be placed inside the "potential-terminal-tube," c_1 (see Fig. 5). A reading of the galvanometer was taken when the end of the capillary tube reached the end of the "potential-terminal-tube." The capillary tube was then drawn up about 3 centimeters or so and another galvanometer reading was made.   The average of these two readings was taken as the average temperature of the ice between the potential terminals.

When the water was frozen, cracks were observed through the ice in the "U" tube, and it was found impossible to obtain ice at low temperatures, by freezing in the tube, without the cracks

These cracks may have a considerable effect on the resistance of the ice.   So the accuracy of the values of the specific resistance as given in this paper, is limited by this uncertainty.
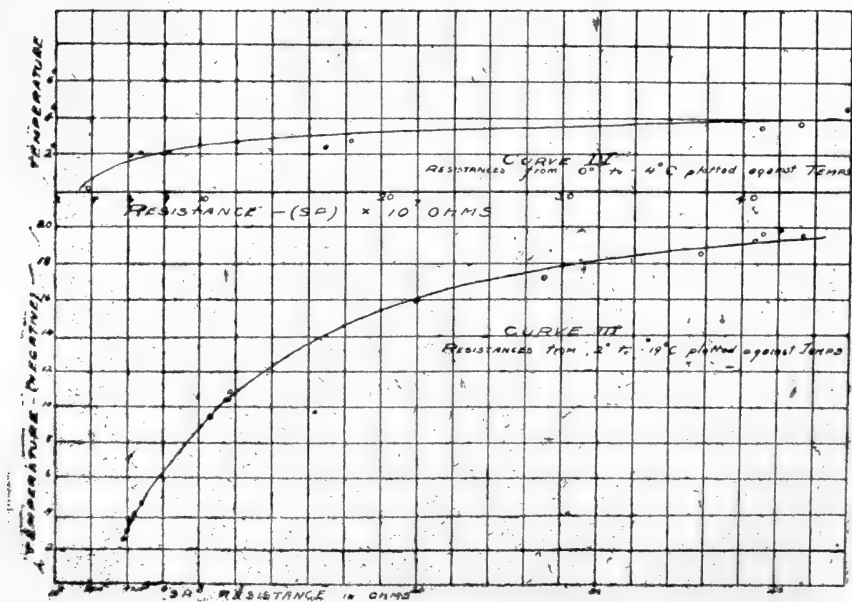
Fig. 8.

A temperature-resistance curve is shown in Fig. 8, and it will be observed that it is nearly *expotential*. This was found to be the case in every curve of six, plotted.

The specific resistance of the ice was found by multiplying the resistance of the ice between the "potential-terminals" by the "cell-constant"[1] of the tube.

To determine the temperature co-efficient of the resistance at different temperatures, the *cotangent* of the temperature-resistance curve, (Fig. 9), was determined graphically at different temperatures, and this was divided by the resistance of the ice at this point. Thus if R_t is the specific resistance at temperature t then the temperature co-efficient at this temperature will be $\dfrac{1}{R_t} \times \dfrac{d\,R_t}{d\,t}$. For the temperature co-efficient curve, see Fig. 9.
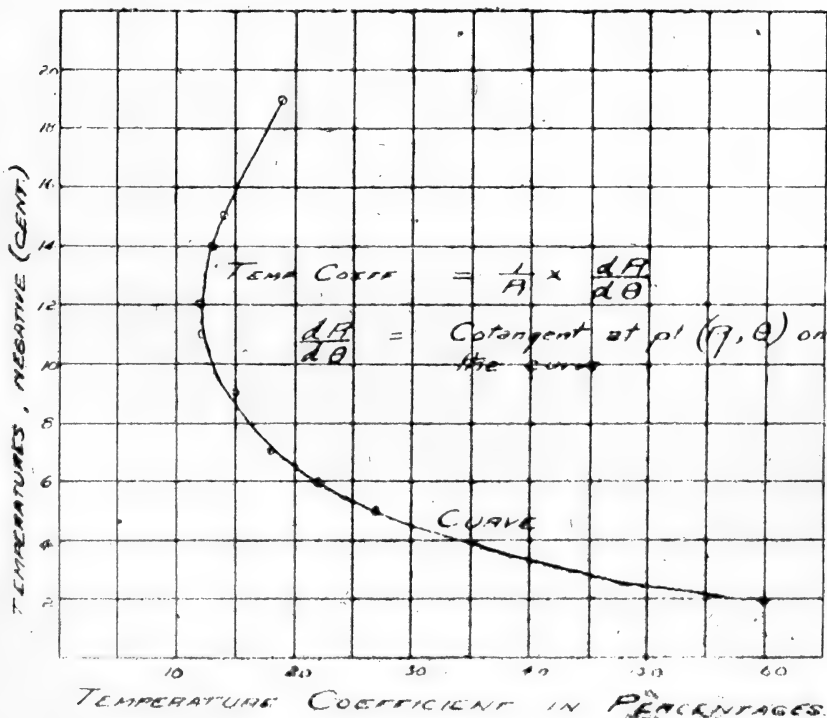
FIG. 9.

1. Kohlrausch, F., Physico-Chem. Measurements.

Summary.

1. The specific resistance of ice has been determined at temperatures ranging from $0°$ to $— 19°C$.

2. The effects of electrolytic-polarization have been eliminated by the method used.

3. *The value of the temperature-co-efficient of the resistance of ice has been determined at different temperatures and its value has been found to be very much higher than the temperature-co-efficient of ordinary electrolytes. It decreases in value as the temperature decreases from zero.*

The values obtained for the specific resistance of ice compare fairly well with those obtained by Ayrton and Perry, using a different method.

In conclusion I wish to thank Dr. H. L. Bronson, who suggested this work, and without whose kind supervision and assistance, this research could not have been undertaken.

Dalhousie University, Halifax, N. S.
        April 20th, 1912.

The Geological Age of Prince Edward Island.—By Lawrence W. Watson, M. A., Charlottetown, P. E. I.

The exact position of Prince Edward Island in geological time has long been a matter of uncertainty. That it was limited in one direction by the Upper Carboniferous and in the other by the Trias, was recognized by all the Canadian geologists who have examined the rocks of the island, notably Gesner, Sir William Dawson, Dr. Ells of the Geological Survey of Canada, and the native naturalist, Francis Bain; but the general similarity of the rocky constituents, the conformability of the strata and the scarcity of fossils rendered the recognition of possible plurality of formations difficult, if at all possible.

The lowest beds, with outcrop on St. Peter's and Governor's Islands in Hillsborough Bay, and on the still more easterly extension of the same anticline at Gallows or Gallas Point, were early recognized as similar in character and geological horizon with the Upper Carboniferous beds of the northern coast of Nova Scotia, and of parts of New Brunswick opposite to Prince Edward Island.

Along the western shore of Prince Edward Island, from Cape Wolfe to Nail Pond, the lowest strata disclose rocks of an almost equally ancient origin as those of the Hillsborough Bay anticline above mentioned.

In some places on the mainland, as about Cape Tormentine, these lowest beds of dark red or brown sandstones with conglomerates and grey streaks (indicating the elimination of colouring matter by vegetable organisms), with plant fossils characteristic of the Upper Carboniferous formation, pass, without stratigraphical demarcation into the red sandstones, impure limestones, and shales which form the bulk of the rocks of Prince Edward Island.

Because of the want of distinct demarcation between the Upper Carboniferous and the next succeeding Lower Permian systems, Sir William Dawson assigned the lowest and middle rocks to his "Permo-Carboniferous" system, but, from the finding at New London of the fossil jaw of an animal, named by Dr. Leidy *Bathygnathus borealis,* which he (as now transpires, erroneously), concluded was a triassic dinosaur—a conclusion accepted by the great palæontologist Cope—Sir William Dawson assigned the district in which the fossil was found to the Trias, the age next succeeding to the Permian.

Sir William Dawson's latest expressed opinions as to the red sandstones of Prince Edward Island are contained in his *Handbook of Canadian Geology* (1889), pages 97 to 101, from which the following summary is compiled:

The Permian System. The Permo-Carboniferous red sandstones of Prince Edward Island and eastern Nova Scotia are typical of the Lower Permian. Their fossils are for the most part generically similar to those of the Carboniferous. The Upper Permian is not represented in Canada. The Permian, or Permo-Carboniferous of Prince Edward Island does not yet admit of any division into distinct groups and it rests conformably on the upper coal formation without any stratigraphical break. It is characterized by a prevalence of sandstones and shales coloured by the red oride of iron.

The Triassic System. The Bunter sandstone (the lowest of the three divisions which gave its name—Trias—to the system) is represented in Canada by the lower new red sandstone of the Bay of Fundy and Prince Edward Island, associated with trappean rocks. Its fossils are conifers and cycads, and the footprints of dinosaurs. The limestones of the Middle Trias of Germany and eastern France are not found in eastern America. To the Keuper sandstone (the uppermost of the triad series) belong the upper sandstones of Prince Edward Island and the Bay of Fundy, where its trappean beds form

the North Mountain of Cornwallis and Annapolis counties. In both Nova Scotia and New England the triassic age was remarkable for the deposition of red sandstone in shallow bays and straits, and for the ejection of great dykes of basaltic and amygdaloidal basic volcanic ash. In Prince Edward Island, "owing to the slight dips of the Permian and Triassic, and their mineral similarity, it has proved difficult to define their boundaries; but the Trias appears to rest in slight troughs of the Permian and to be partly composed of its rebris."

Thus Dawson's accrediting to Prince Edward Island, beds of Triassic origin was doubtless due to the opinion of Leidy (endorsed by Cope) that the fossil, *Bathygnathus borealis,* Leidy found at New London, was a dinosaur characteristic of the Trias. In a letter to Francis Bain, Sir William wrote as follows: "Look well to the north side of the island for the true Trias." Bain was such an enthusiastic believer in the existence of Triassic deposits in Prince Edward Island, that he contributed to the *Canadian Science Monthly,* in 1885, an article, entitled, "Bounding the Trias," in which he defines the supposed limits of the formation, using, as a strong claim, the surface configuration of the country. According to this writer, the surface of the Permian districts is "like the gentle swelling of the summer sea," while that of the Triassic is "like a sea torn by the wildest conflict of contending winds and currents." He further defines the different characters of the sandstones of the two systems: "The Triassic consists of thick-bedded sandstones, and where rests on similar beds of the Middle Permian, it is difficult to distinguish between the two. But where it rests upon the uppermost beds of shale and fissile sandstones, the distinction is quite marked, and especially in scenic effect. . . . The Triassic sandstones are distinguished from the Permian by having less dark carbonaceous markings in them. There are fewer shales and no calcareous conglomerates, although some of the sandstones are indurated with lime. There are few well preserved fossils in the system so far as we have yet discovered. My fieldbook

contains drawings of over thirty different varieties of plants, but so indifferently preserved that not more than three or four of them could with certainty be referred to their proper species. Yet the group is readily recognized as distinct from similar remains in the Permian strata below . . . . *But these* [Triassic plant fossils] *would not have been sufficient to characterize the system if they were not associated with an undoubted Mesozoic dinosaur, Bathygnathus borealis."* (The italics are mine. L. W. W.)

In view of the considerations submitted by Bain, Dawson in 1885 (*Canadian Record of Science,* vol. i, no. 3) wrote thus: "The general result, as far as the subdivision of the beds is concerned, would seem to be that the lower series is distinctly Permo-Carboniferous, that its extent is considerably greater than we supposed in 1871, *that there is a well-characterized overlying Trias"* (italics, L .W. W.), and that the intermediate series, whether Permian or Lower Triassic, is of somewhat difficult local definition, but that its fossils, as far as they go, lean to the Permian side.

Dr. Ells, of the Canadian Geological Survey ,in his report of his observations made in 1902, writes as follows: "With the exception of this fossil (*Bathygnathus*) from the New London area, it may be said that all the available evidence points to the opinion that the red sandstones and shales, of which the island is largely composed, may all be assigned to the Carboniferous horizon, or as some geologists prefer to call them, Permian.

In this somewhat uncertain state rested the information as to the age of the latest rocks until 1905, when, in an article published in *Science* (new series, vol. xxii, no. 550, p. 52) E. C. Case, an eminent authority upon the fauna of the permian beds of North America, disputed the identity assigned to the New London fossil, and stated his conviction that the fossil *Bathygnathus* instead of being the *lower* jaw of a Triassic dino-saur was the *upper* jaw of one of the most specialized

of the Pelycosaurs, such as occur in the Texas region, probably a Demetrordon or Nausaurus, "characteristic of, and not surviving the permian age."

Simultaneously, and independently, Dr. Von Huehne published a paper (*N. Jahrb. f. M. G. u. P. Beilage,* band xx., p. 343) in which he arrived at the same conclusion as to the nature of the fossil and the age of the beds in which it was found. In his "Revision of The Pelycosauria," published by the Carnegie Institution of Washington (1907), Mr. Case restates his conviction that the animal was a dinosaur characteristic of the Trias, but one of the Pelycosauria, "a highly specialized, primitive side branch of the Rhyncocephalia, which seemingly became extinct at the end of the Permian age."

Thus, as the existence of Triassic deposits in the northern and central parts of Prince Edward Island depends, even according to the enthusiastic champion of the theory, Francis Bain, entirely upon the supposition that *Bathygnathus borealis,* Leidy, was a dinosaur, and, as the animal has been adjudged a pelycosaur of Permian time by indisputable authorities, the conclusion is inevitable that, in the present state of our knowledge, Triassic deposits cannot be said to occur in this region, and that the whole rock system of the island is referable to the Permo-Carboniferous age.

THE CANADA GROUSE (DENDRAGAPUS CANADENSIS) IN CAPTIVITY; ITS FOOD, HABITS, ETC.—BY WATSON L. BISHOP, Dartmouth, N. S.

The habitat of the Canada Grouse, commonly called in Nova Scotia the "Spruce Partridge" is, northern North America east to the Rocky Mountains, from the northern portions of New England, New York, Michigan and Minnesota to the limit of trees reaching the western coast in Alaska.

In this province it is mostly found in the spruce forests and swamp regions far from the habitation of man. It is very seldom seen in the vicinity of fields and clearings, which are the favorite resort of the Ruffed Grouse (*Bonasa umbellus*).

A few years ago I kept quite a number of these birds in a large enclosure for several years and this gave me an excellent opportunity to study their food and habits, an occupation of which I was very fond. Since that time I have had many inquiries in regard to the food and care of these birds in captivity. I am, therefore, writing this with a view to assist any who may wish to experiment in the domestication of this interesting species.

My first bird, a male, was got about the middle of September. I put him in a small pen with a black duck (*Anas obscura*) also a male; but they did not get along well together. The grouse kept continually nagging the duck about the pen, so that I had to separate them until I had built a larger enclosure (about 30 feet square). There they got along on more friendly terms. Not long after, I obtained three females. The question to be solved then was, how to feed them, which I soon learned was rather a difficult matter; for two of them sickened and died within three weeks. When I

(150)

found they were ailing, I tried every means to restore them to health but without avail. I had them replaced by others, however, as soon as I could get them. This was not long as I had offered a liberal price. I then began to study what their food supply consisted of in their wild state. I therefore carefully examined the contents of the crops of those brought me to be mounted, and found that their food consisted of the foliage of the red and white spruce, some crops containing a few buds of hacmatack or larch (*Larix americana*), and sometimes a few blades of grass.

The tops of several young spruce trees seven or eight feet long were then cut and stood up in the pen. As soon as they were in place the birds flew up in them and commenced feeding, and it was interesting to see how eagerly and adroitly they would strip the spine-like leaves from the branches. In gathering these spines from the twigs the bird makes a stroke nearly parallel with the branch on which they grow, striking outward towards the end of the limb, gathering perhaps a half a dozen leaves at a time. Then by a twisting movement of the head, the spines are partly broken and partly bitten off, leaving a small portion still in place on the twig. These movements are as rapid as those of a domestic fowl picking up corn.

These tree tops served for roosting places as well as food, and were replaced whenever needed to keep them fresh and good. In selecting trees for this purpose, the young thrifty growing ones must be got, for the birds will not eat those which are old and slow growing as the foliage is tough and hard. By pinching off the spines with the fingers it is quite easy with a little practice to select those which are most acceptable to the birds. During the winter this food was supplemented by a little bread and grain, wheat and buckwheat. Oats and barley were not relished. As the spring advanced and the spruce buds began to swell, they were eagerly eaten by the birds, and even after the new shoots had grown to a length of two or three inches the whole new growth was eaten. The cones were

also fed upon while young and tender. I lost one fine bird by eating cones after they had become too hard and woody to be digested. This seemed to cause great distress and pain. The sick bird would sit for hours on the ground with his body quite upright, and keep continually moving his neck and body from side to side. I could not understand the cause of this strange conduct until later.

After a few days in this condition, during which time he would eat nothing, he died. On examination I found a hard spruce cone which had lodged in the narrow passage before reaching the gizzard. This explained the strange position and movements of the body during the illness. He was trying to force the obstruction along and thus ease the pain. Gangrene had set in where the cone lodged and ultimately resulted in death.

I do not think this accident would have happened in a wild state as there would be a greater supply to select from and the hard cones would not have to be eaten. At this season almost any kind of tender young grass would be eaten. Later when the common grasses became tough and hard, clover and dandelions would be eaten, and these were supplied by cutting up the sod on which they grew and placing it in the pen. Grasses supplied in this way would not dry up as cut grasses. They would keep fresh and green until all was used up. Other food such as green peas and wild berries, bunch berries, and winter green particularly, were relished best. At all times in the year it is necessary to keep a good supply of fresh spruce where they can have all they want. This being one of their most natural supplies, tends to keep them in good health.

One winter, in February, a man brought me two of these birds in a small basket, just large enough to contain their bodies, with a cloth tied over the top having two holes to allow their heads to stick out. They were brought in on a slow ox team a distance of 15 miles. The two birds having been confined to so small a space and covered with a cloth became so hot that one was dead when it arrived, and the other did not

look as though it would live more than a few minutes. Its head was lying over to one side with eyes closed, and it seemed to be dying. I took it from the basket and gave it some pulp of grapes which revived it. Its body having been in such a hot place, and with no water to drink, it was dying of heat and thirst. With good care it soon recovered and became smart, and that spring laid eight beautiful eggs which I presented to Mr. J. Parker of Philadelphia.

These birds became very tame, in fact as tame as any domestic fowls, and would run to meet me at the door when I went to feed them.

The coloring of the eggs is deposited entirely on the surface and can be easily washed off when the egg is first laid. So soft is this pigment and so easily marked that the eggs will sometimes show scratches on the large end, caused by coming in contact with the coarse parts of the nesting material when being laid. It also fades if exposed to the light, so that eggs which are nest-worn or have been exposed to light for any length of time, lose much of their beauty.

The color of a fresh laid egg is almost exactly like that of the outer case of new young buds of the red and white spruce on which they feed. I often noticed that when they were fed plentifully on this food, the eggs would be more highly colored.

The birds usually lay an egg each alternate day, but sometimes there would be two days between in which the supply of pigment seemed to have been collecting to be deposited on the next egg, which is of a much deeper color than that of the normal egg.

A Few Measurements on the Electrical Conductivity of Acetophenone Solutions of Certain Organic Bases and Acids.—By H. Jermain Maude Creighton, M. A., M. Sc., Dr. Sc., Lecturer on Physical Chemistry, Dalhousie University, Halifax, N. S.

In an investigation[1] recently carried out by the author, it was found that the degree in which the decomposition of bromcamphor-carboxylic acid, in acetophenone solution, was accelerated by various alkaloids and other organic bases, was in most cases parallel to their affinity constants. As these affinity constants are for water solutions, it seemed desirable to determine whether the same order held when the conductivity of the bases was measured in acetophenone solution. Accordingly the following measurements were made.

Measurements on the conductivity of a number of substances in acetophenone have been made by *Dutoit* and *Friderich*[2], by the ordinary method of Kohlrausch. With the substances under investigation, however, it was found that this method was not sufficiently accurate, on account of the self-induction and electrostatic capacity effects that arose with the large resistances it was found necessary to employ.

The method employed, therefore, was the condenser method used by Nernst[3] and Miss Maltby[4]. By this method the resistance of the electrolyte is determined through substitution in one arm of a Wheatstone bridge arrangement, which consists of four electrolytic resistances. Here the disturbance arising from electrostatic influences is eliminated by means of two condensers of variable capacity. The procedure is the same as in the determination of the dielectric constant, wherein the galvanic conductivity is compensated.

1. Creighton, H. J. M. : Dissertation, Zürich, 1911.
2. Dutoit, P. and Friderich L. : Bull. Soc. Chim., **19**, 321, (1898).
3. Nernst, W. : Zeitschr. f. phys. Chem., **14**, 622, (1894).
4. Maltby, M. E. : *ibid.*, **18**, 133, (1895).

The apparatus used consisted of the following:

1. An induction coil and accumulator.
2. Liquid resistances (electrolytic).
3. Two variable condensers.
4. An electrolytic cell for the liquid being investigated.
5. A telephone.

The glass vessel used to hold the electrolytic resistances was of the form shown in figure 1. The arms AB and CD are about 10cm. long, the internal diameter of the former being 5mm. and of the latter 0.8mm. The platinum electrodes which fit inside these arms may be raised or lowered by turning. Both
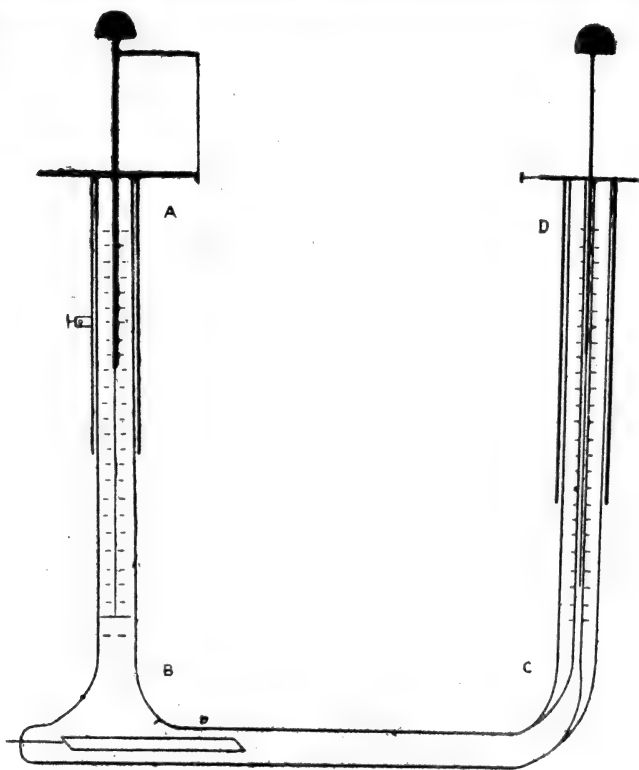
FIG. 1.

arms of the tube, as well as the metal disc at the top of AB, are graduated; AB in half millimeters and CD in millimeters. One complete turn of the larger electrode raises it 0.45mm., and since the metal disc at the top is divided into 100 parts, it is possible to read a change in the height of the electrode to a few 45/10000mm. The narrow arm of this resistance tube is used for measuring very high resistances, while the wider arm is used for smaller. By placing the unknown resistance behind the measuring resistance, or in shunt with it, it is possible to measure resistances varying from one hundred to thirty million ohms, within a few per cent.
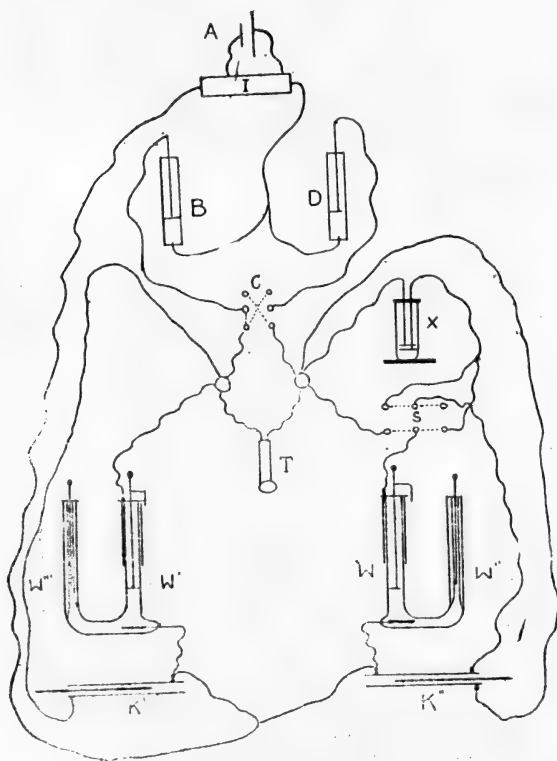
Fig. 2.

A 2/3-normal solution of mannite and boric acid, whose small negative temperature coefficient was compensated with potassium chloride (0.06g. per liter of the mannite solution), was used as the electrolytic resistance.

A diagram of the complete apparatus is shown in figure 2. A and I are the accumulator and induction coil. W, W', W'' and W''' are the arms of the bridge (W and W' are 5 mm. in diameter, and W'' and W''' are 0.8mm.); D and B are two resistances which remain constant during an experiment; K' and K'' are variable condensers; T is the telephone; X is the cell for the unknown resistance; S is a two-way switch for introducing X behind W or in shunt with it, and C is a commutator used for making D and B equal.

The resistances W, W', W'', and W''' were calibrated by means of a known electrolytic resistance in the cell X. By using the same cell, for the acetophenone solutions of the substances under investigation, their resistances were readily calculated from the length of resistance W required to give a balance[1].

In order to test the accuracy of this method, the conductivity of a sample of ordinary distilled water, the conductivity of which was also measured by the Kohlrausch method, was determined. By the first method it was found that at 15°.0 $\kappa = 1,23 \ 10^{-5}$, and by the second method, at the same temperature, that $\kappa = 1,17 \ 10^{-5}$.

The acetophenone used in the following measurements was first purified by distillation and recrystallization. This acetophenone had a specific conductivity of $\kappa = 2,02 \ 10^{-7}$.

The measurements given in the following tables were all made at room temperature (16-17°).

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1. For a detailed description of the method, apparatus, etc., see Maltby, M. E. loc. cit.

TABLE I.

Conductivity of some Substances in Acetophenone.

Liter per Mol, V.	Spec. Conductivity corr. $\kappa.10^7$	Mol. Conductivity corr. $\mu \cdot 10^4$
	Piperidine*	
2	5.37	10.74
4	4.54	18.16
8	3.76	30.08
	Camphor–carboxylic acid	
2	29.1	58.2
4	19.9	79.6
8	12.5	100.0
16	6.7	107.5
32	3.5	111.7
	Bromcamphor-carboxylic acid	
2.75	30.7	84.4
5.50	19.1	105.0
11.00	11.5	126.5
22.00	6.0	132.0
	Piperidine camphor-carboxylate	
2	172.4	344.8
4	87.6	350.4
8	50.8	406.4
16	30.8	492.8
32	18.3	585.6

* The acetophenoneused with piperdine had a specific conductivity of $\kappa = 2.87 . 10^{-7}$.

On account of the readiness with which acetophenone solutions of bromcamphor-carboxylic acid decompose in the presence of small quantities of organic bases[1], it was not possible to measure the conductivity of salts of this acid. In order to obtain some idea of the order of the conductivity of the salts of bromcamphor-carboxylic acid with weak bases, an acetophenone solution, which was 0.3305 molar with respect to acid and 0.0113 molar with respect to conine, was prepared and its conductivity immediately determined. The specific conductivity of this solution was found to be $65.0 \cdot 10^{-7}$; its molecular conductivity was, therefore, $196.6 \cdot 10^{-4}$.

The conductivities given in the foregoing table have been corrected for the conductivity of the solvent.

In the following table there is given the specific conductivity of half normal acetophenone solutions of a number of weak organic bases; the specific conductivity of half normal acetophenone solutions of the salts of these bases with camphor-carboxylic acid and, lastly, the specific conductivity of half normal water solutions and the dissociation constants of some of the bases. In this table the bases are placed in the order of their dissociation constants in water solution.

1. Creighton, **H. J. M.** : loc. cit.

TABLE II.

BASE.	Half normal acetophenone solution.				Half normal aqueous solution.	Dissociation constant[2] at 25° (water solution.)
	Spec. conductivity of the base. $\kappa. 10^7.$		Spec. conductivity of the carboxylate. $\kappa. 10^7.$		Specific conductivity of the base[1]. $\kappa. 10^8.$	$\kappa.$
	uncorr.	corr.	uncorr.	corr.		
Aniline	2.13	very small.	38.1	36.1	....	$4.0 \cdot 10^{-9}$
Quinaldine	2.11	"	71.8	69.8	....	....
Quinie	2.79	0.77	88.5	86.7	....	....
Quinidine	2.83	0.81	88.2	86.2	....	....
Nicotine	3.72	1.70	258.4	256.4	....	....
Benzylamine	5.86	3.84	176.3	174.3	0.94	$2.4 \cdot 10^{-5}$
Triisobutylamine.	2 75	0.73	566.1	564.1	....	$2.6 \cdot 10^{-4}$
Diisobutylamine..	2 42	0.40	salt not	soluble.	....	$4.8\ 10^{-4}$
Isoamylamine. ..	6.82	4.80	salt not	soluble.	4.2	$5.0 \cdot 10^{-4}$
Tripropylamine ..	2.30	2.28	721.7	719.7	....	$5.5 \cdot 10^{4}$
Conine.	3.90	1.88	37.3	36.3	6.9	$1.3 \cdot 10^{-3}$
Piperidine	8.24[3]	5.37	175.3[3]	173.3	7.3	$1.6 \cdot 10^{-3}$

1.   The numbers in this column have been obtained by extrapolation of measurements by G. Bredig (Zeitschr. f. phys. Chem, **13**, 289, 1894), after converting the values expressed in units based on Siemens unit into values expressed in the international unit.

2.   Bredig, G. : loc. cit.

3.   The acetophenone used with the piperidine preparation had a specific conductivity, $\kappa = 2.87.10^{-7}.$

From the foregoing conductivity measurements, it will be seen that, where conductivities were measured at different dilutions, the molecular conductivities increased with dilution, as in aqueous solutions; that the "electrolytic dissociation"[1] of the above bases must be exceedingly small; and, also, that the "electrolytic dissociation" of their salts with camphor-carboxylic acid, although twenty to several hundred times greater, is still of the same small order. There is reason to believe that the salts of these bases with bromcamphor-carboxylic acid are probably "electrolytically dissociated" to a much greater extent.

It was hoped to have been able to determine the dissociation constants of the different bases in acetophenone solution, but this was found to be impossible, owing to the large errors introduced by the extreme smallness of the conductivities and the rapidity with which the specific conductivities of the solutions approached the specific conductivity of the solvent, even at small dilutions. From the last two columns of table 2, it will be seen that the specific conductivities of equi-molar aqueous solutions of benzylamine, isobutylamine, conine and piperidine, are relatively proportional to their dissociation constants. In view of this it is possible that the specific conductivities of equi-molar acetophenone solutions of the different bases, which are about ten thousand times smaller than for water solutions of the same concentrations, are also a measure of their dissociation constants in this solvent. From the measurements made it would appear, then, that the dissociation constants of the different substances employed are *very much smaller in acetophenone solution than in water*. This supposition is in harmony with the Nernst-Thomson rule, which shows clearly the close parallelism between the dielectric constant of the solvent and its dissociating power, since Walden has recently

1. Here by "electrolytic dissociation" and "electrolytically dissociated" are meant any condition of good electrolytic conduction, without necessarily assuming that the relations are as simple as those which occur in water solution.

found the dielectric constant of acetophenone[1] to have the small value of 18.1-18.6 at room temperature. It is further to be observed that if our conjecture be correct, namely, that with equi-molar actophenone solutions the specific conductivity is an approximate measure of the dissociation constant of the solute, then the relative strengths in acetophenone of the bases used above differ somewhat from those in water. Thus conine which, in water solution, is a stronger base than isoamylamine, for example, is weaker than the latter in acetophenone. On the other hand the relative position of piperdine is the same in either solvent.

The measurements embodied in this paper were carried out at the Laboratorium für electro und physikalische Chemie, der eidgenössischen technischen Hochschule, Zürich, Switzerland, in February, 1911, at the suggestion of Professor G. Bredig.

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1. Walden, P. : Zeitschr. f. phys. Chem., **70**, 573, (1910).

Dalhousie University,
    Halifax, Nova Scotia,
        May 3rd, 1912.

MASTODON REMAINS IN NOVA SCOTIA.—BY HARRY PIERS,
Curator of the Provincial Museum, Halifax.

While recently engaged in preparing suitable labels for
specimens of a femur and molar tooth of the American Mas-
todon from Cape Breton island, which are preserved in the
Provincial Museum at Halifax, I was led to make inquiries to
ascertain as far as possible just what was known regarding
their history, either in literature or as tradition among the
old people of the localities where they were discovered. It
was found that little was on record, and in fact the precise
spots where they were unearthed were not at all definitely
known, and other points required clearing up.

In order to facilitate future reference, I now venture to
present a concise systematized account of all that is known of
the only authentic existing remains of the Nova Scotian
Mastodon, including interesting particulars from old persons
who still remember well the original discovery. The time for
rescuing any unrecorded facts was almost gone, and in a few
years not a man would have remained who could have person-
ally recalled any of the circumstances of one of the most inter-
esting palæontological finds ever made in this province.

At the outset it may be observed that the paper does not
intend to deal with the question of geological age, but it may
be stated that there seems no reason to question the generally
accepted conclusions on this point.

. The Mastodons, of which about thirty species have been
described, belong to the suborder Proboscidea (the Elephants),
primative forms of which lived in Egypt in the Middle Eocene,
showing that Africa was the point of dispersion of the animals
cf this suborder. Mastodons made their appearance in Europe
at least as early as the middle of the Miocene epoch and also

soon afterwards in Asia. From Asia they migrated to North America, and are there first met with in the Deep River and Loup Fork (Upper Miocene) beds of the central states. In the next ascending series, that of the Pliocene epoch, we find them still existing in Europe, Asia and North America (where they are rather common), and they then here found their way into South America. Finally in the Pleistocene epoch they are persisting and common in North America and have spread in South America, while they have disappeared from Asia and Europe, being there survived, as well as in Africa, by the existing genus *Elephas*. Some remains in the United States are said to have been found in association with stone implements, which if so, would indicate that there at least they must have survived till after the advent of man.

Name and Range.

Name and synonyms.—The species to which the Nova Scotian remains are referred, is the AMERICAN MASTODON, *Mastodon americanus* (Cuvier), which is considered to be synonymous with *M. ohioticus* (Blumenbach) and *M. giganteus,* Cuvier. As only a couple of members of a skeleton (a thighbone and a molar tooth) are known from Nova Scotia, their reference to this species must for the present be considered as probably, but not positively, correct.

Range of the species.—Remains of the species occur in various parts of North America as far south as Texas. They are more or less common in alluvial deposits such as occur on a small tributary of the Osage river, Burton county, Missouri, and in a peat deposit at "Big-bone-lick," Kentucky; also in Orange county, and near Cohoes falls on the Mahowk and elsewhere in the lower Hudson valley counties, New York; and likewise in Indiana, New Jersey, Ohio, and numerous other places. In Canada they have been reported from Ontario, Manitoba, the Yukon, and Nova Scotia.

Femur.

Description.—The first specimen in the museum is a right femur (thigh-bone) of an adult animal, agreeing generally in form with that of *M. americanus.* It is in a very good state of preservation, the bone tissues being firm and practically unaltered, but longitudinally cracked in a few places. Remains of the cartilege may still be seen on a few places on the articular surface of the head of the bone. In parts, particularly about the region of the extremities (trochanter major and the condyles) the outer surface is somewhat worn off, exposing the cellular under parts, In the vacinity of the internal trochanter a portion of the bone has been broken off.

Measurements.—Greatest length from head to inferior extremity near condyles, 3 ft. 10.50 in. Diameter of body of femur in middle, 7.35 in.; anterior-posterior diameter at same place, 4.60 in. Greatest width from head to region of trochanter major, 1 ft. 5.50 in. Diameter of head, 8 in.; diameter of neck, 6.40 in.; anterior-posterior diameter at last-mentioned place, 5.60 in. Diameter at condyles, 10 in.; anterior-posterior diameter at condyles, 7.75 in. These measurements would indicate an animal that would have measured about 10½ feet to the shoulders, which very nearly equals the height (11 feet) of Dr. J. C. Warren's immense Mastodon skeleton from Newburg, N. Y., now in Boston.

Locality where found, and collector's name.—Found by the late Alexander McRae, at a depth of about five inches from the surface, in meadow soil containing some sand, on "intervale land," on farm of said McRae (now owned by his nephews, Duncan and Daniel McRae), one-half a mile westward of the road at the schoolhouse, Lower (Settlement) Middle River, Victoria county, Cape Breton island, Nova Scotia.* The precise spot where the bone was found is close

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* Hon. W. F. McCurdy of Baddeck. writes me that he thinks some of the farmers at Middle River thought it might benefit them if they were to cut a canal through a gravel bank and so change the course of the river. They accordingly made the canal with the result that the river cut away a large quantity of gravel, etc., and so revealed the Mastodon remains. Honeyman states the femur was ploughed up.

to the eastern bank of the Middle river, and $1\frac{1}{2}$ miles south
15° east (true bearings) of the junction of Leonard McLeod
brook (Middle River) with the Middle river.   Compare
Geological Survey of Canada, Nova Scotia map sheet no. 13.
(*Vide* information supplied by Duncan McRae, nephew of the
original finder).

The oldest mention of the bone in a Mechanics' Institute
inventory of about 1835, merely gives the locality as "the Island
Cape Breton."   The earliest label, in Dr. Honeyman's writ-
ing, of about 1870, states it was found at "Middle River,
C. B."   Honeyman in his *Giants and Pigmies* (p. 87) says it
was ploughed up on the intervale of Walker's farm, at Middle
River, about nine miles from its mouth.   The McRae farm,
however, where the bone was discovered, was never owned by
a Walker, nor was there a Walker family settled there.   Alex-
ander McRae had inherited it from his father, and it is still
possessed by McRaes.

Date of discovery.—The femur was found about 1834 or
a few years earlier.   One of the latest stick-labels on it,
in Honeyman's writing, gives the date as 1842, but this is
an error, as well as his statement in *Giants and Pigmies* that
it was found about forty years before, that is about 1846.   The
first record I find of it is in a manuscript list of articles in
the Halifax Mechanics' Institute (founded in 1831), undated,
but written on paper watermarked "1833" and therefore pre-
pared approximately about 1835, where it is entered as
"Right thighbone of the Fossil Elephant found in the Island
Cape Breton, [Presented by] Peter H. Clark, Esq."   Then
in a manuscript inventory of apparatus, models and specimens
in natural history in the museum of the same institution, pre-
pared by C. Creed in June, 1839, we find listed the "Femur of
fossil Mastodon."   An inspection of lists of donations to the
Institute, usually given annually in the *Nova Scotian* news-
paper, may fix the date.   The late Alfred F. Haliburton, of

Baddeck, told me some years ago, that according to his recollection the date would be approximately about 1836.

Donor's name.—From Alexander McRae the specimen passed to Peter Hall Clarke of Sydney, afterwards (1844) a member of the legislative council, who presented it to the then recently organized Halifax Mechanics' Institute in whose museum it remained until it was transferred to the Provincial Museum of Nova Scotia on the latter's foundation in October, 1868, where it is still preserved.

Geological age.—This bone may be fairly safely assigned to the very close of the Pleistocene (or Glacial) epoch or the opening of the Recent (or Post-glacial) epoch. The underlying formation is carboniferous limestone.

Dawson in the first edition of *Acadian Geology* (1855) speaks of its having been found in superficial gravel, and says it probably belonged to the close of the glacial or drift period, and that the species was probably extict here before the introduction of man. Honeyman in his *Giants and Pigmies* (1887), pp. 87-89, states that he had hitherto held the opinion "that it was of post-glacial age, that it was contemporary with the American mammoth, both being of Pleistocene age and of the Champlain period," but on certain geological considerations he says he has now been led to regard it "as contemporary with the Europeans." Does · he mean the European mastodons? Dawson in his *Handbook of Geology* (1889), p. 157, very slightly modifies his earlier view, and refers it to the post-glacial or late glacial age, "possibly" extinct before the introduction of man, though he rightly notes that the Micmac Indians seem to have had traditions of its existence.

Remarks.—Honeyman (*Giants and Pigmies*) says the discovery of this bone caused considerable excitement, and that Admiral Dundonald (who was on this station from 1848 to 1851) and Dr. Abraham Gesner visited and explored the spot with the expectation of making further discoveries of remains,

but without success.* As the place is thoroughly cultivated, it is exceedingly doubtful if mere superficial examination would disclose anything further, but it is quite possible that the sub-soil may yet hide other parts of the skeleton.

References and figures.—Manuscript lists of articles in the Halifax Mechanics' Institute, *circa* 1835, and June, 1839. Dawson (Sir J. W.), Acadian Geology, 1st ed., 1855, pp. 57-58; 2nd ed., 1868, p. 83, with figure on p. 84; 3rd ed., 1878, do.; 4th ed. (Geology of Nova Scotia, etc.), 1891, do. Honeyman (Rev. D.), Giants and Pigmies, 1887, pp. 87-88. Dawson (Sir J. W.), Handbook of Geology, 1889, p. 157. McRae (Duncan), information in manuscript furnished by him, February, 1912.

Molar Tooth.

Description.—The tooth is a molar, probably a second one, but I am not able to say whether it is from the right lower or the left upper maxilla. It has three well defined transverse "nipple ridges" on the crown, but with very inconspicuous tubercles thereon, and no cement in the hollows of the enamel, etc. The roots or "fangs" are two, the anterior one much smaller than the posterior one. In the latter, which has per-haps been slightly broken or eroded at the apex, is the nerve and artery canal open at the apex of the root and bifurcating at the inner extremity where it communicates with the pulp-cavity. The enamel is jet black externally, and white within. The black layer occupies from nearly nothing to about one-quarter of the total thickness of the enamel. The dentine is of cream colour. The tooth was in good preservation when found, but unfortunately the finders undertook to investigate its struc-ture with the aid of a blacksmith's hammer and vice, and so

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*D. J. Mc Rae of Baddack, a relative of Alexander, says that in 1850 Admiral Dundonald with his ship was in the Bras d'Or. and having heard of the finding of the Mastodon remains, went to Middle River with a number of his sailors, and that the Admiral took away to England a broken " tooth " (tusk ?) which had been found there but that it was afterwards returned to Nova Scotia. While this fixes the time o Dundonald's visit, there can be little or no doubt that the tusk from Middle River was taken from there prior to 1835. See remarks on the Tusk

succeeded in breaking off part of one of the end transverse ridges, as well as about half of the enamel, thus leaving the yellowish dentine of the crown exposed. Otherwise it is in excellent condition.

Measurements.—Greatest length of crown, 4.35 ins.; greatest width of crown, 3.10 ins.; summit of posterior transverse ridge to apex of larger root, 3.90 ins.; summit of anterior transverse ridge to apex of smaller root, 2.80 ins.; height of crown from summit of transverse ridges to base of roots, 1.60 in.; greatest height of transverse ridges (apices broken off), .75 in., but original height probably 1.10 in.; thickness of enamel, .16 in.; depth of nerve canal to its bifurcation, 1.30 in.; greatest diameter of nerve canal at exterior opening, .50 in.

Locality where found, date, and collector's name.—Found in 1859 at Baddeck, Victoria county, on the northwestern side of Little Bras d'Or lake, Cape Breton island (*vide* Dr. Honeyman's original label). This is 8½ miles east-southeast of the place where the femur was discovered. I had suspected that possibly the tooth might have been obtained at the latter place and carried to Baddeck, but Duncan McRae assures me that he never heard of such a tooth having been found on his farm at Lower Middle River. It was presumably found by a resident of the district, but his name is not now known. Dawson is in error in saying it was discovered by Dr. Honeyman. Strange to say, Hon. W. F. McCurdy, of Baddeck, writes me that he has been unable to find anyone who now knows anything of such a tooth having been found at Baddeck or Baddeck river.

Donor's name.—Dr. Kier of Princetown, Prince Edward Island, obtained it from the finder, and shortly prior to 1862 gave it to Dr. Honeyman, who deposited it in the Provincial Museum in 1868, where it is still preserved.

Geological age.—Doubtless precisely the same as in the case of the femur.

Remarks.—The size of the tooth indicates that it belonged to an individual smaller than that from which the femur was derived. These specimens therefore show that two Mastodons at least existed in Cape Breton island, no doubt both belonging to the same species. The tooth was shown by Dr. Honeyman in the Nova Scotian palæontological collections of the exhibition at South Kensington, England, in 1862, and he then compared it with many teeth of *M. americanus* in the British Museum, with which it agreed.

References and figures.—Dawson (Sir J. W.), Acadian Geology, 2nd ed., 1868, p. 83, with figure showing outer side, reduced to about half natural size, on p. 84; also in subsequent editions. Honeyman (Rev. D.), Giants and Pigmies, 1887, p. 88.

Tusk.

Tusk.—In the beforementioned manuscript list of articles in the Halifax Mechanics' Institute museum, prepared about 1835, there is listed a "Large tooth of some unknown animal found in Island Cape Breton, presented by Mr. Le[o]nard," as well as the right thigh-bone already described. In Creed's inventory of June, 1839, we find "Femur of fossil Mastodon; tooth of do. do.," and Dr. Honeyman has written opposite the "tooth," *not found,* that is when he took over the museum in 1868.

Dawson (*Acadian Geology,* 1st ed., 1855, p. 57) says that the thigh-bone in the museum of the Mechanics' Institute and some fragments of a tusk were the only remains of the Mastodon he had up to then actually seen in the province, and furthermore states that he had not seen any teeth. As Dawson was very familiar with the contents of the Institute museum, there can be no doubt that he considered the so-called tooth to be fragments of a tusk or highly developed upper incisor tooth of the animal.

Honeyman (*Giants and Pigmies*, 1887, p. 88) states that he found in the Mechanics' Institute museum tusks which were supposed to be parts of the Mastodon tusks, but which he says were tusks of the walrus. It seems almost positive that he was in error about this, and that the original tusk had been lost, or loaned for examination and never returned, prior to his taking over the collections in 1868, and that he had come to the conclusion that one of the walrus tusks which he later found in the museum must have been mistaken for it.

That a tusk or part of a tusk was actually found on the McRae farm at Lower Middle River, Victoria county, is very strongly supported by Duncan McRae (memorandum of February, 1912) who distinctly remembers that a "large tooth [i. e., tusk] shaped somewhat like a sickle" was found on the McRae farm a short distance from where the thigh-bone was discovered, and I suppose at or about the same time, and that a man whose name he does not know, who had been sent down from Halifax, went there and took it away to Halifax. It was so large that this man, when he departed with it, "slung it across his shoulder," but the incident took place so long ago that McRae does not remember the exact length of the relic. This, in my opinion, was without doubt the tusk or "tooth" which was afterwards in the Institute museum, presented by a Mr. Leonard, listed in the beforementioned inventories, seen by Dawson prior to 1855, but which was lost before 1868. The sickle-shape shows it was a long "tusk," not an ordinary molar tooth. McRae says he had never heard of anything else resembling a tooth having been found at Lower Middle River, nor any other remains but the thigh-bone. The Mr. Leonard mentioned as having presented the so-called "tooth" to the Institute museum, was very likely Charles E. Leonard who was prothonotary, etc., of Sydney in 1833, or some other member of that family.

Other Remains.

Dawson (*Acadian Geology,* 1st ed., 1855, p. 58) says that while the femur and tusk fragments were the only remains he had then seen in the province, yet he was informed that others had been found, though several of the best specimens had unfortunately been lost by shipwreck.

The late Alfred F. Haliburton of Baddeck, Victoria county, sergeant-at-arms of the house of assembly, assured me, about 1901, that he was with those who brought away the Mastodon remains or some of them in a canoe from Middle River. I distinctly understood him to refer to that locality when he was speaking, and he thought the date would be about 1836 according to his recollection. He said they also had a skull or part of a skull of the animal, but it was lost by the upsetting of the heavily-laden canoe, presumably in the Middle river. It would seem as though this was what Dawson referred to when he said that some of the best specimens had been "lost by shipwreck." Duncan McRae, however, writes me that he does not remember ever having heard of this skull or of any specimens having been thus lost, the only remains he recalls being the femur and the "sickle-shaped tooth" as he calls it.

The Possibility of finding other Remains.

One purpose of this paper has been to draw attention to the advisability of making search here for further remains of the Mastodon, as well as to make a systematic record of all the obtainable information regarding such as have been already discovered.

It seems hardly possible that we have already discovered the only existing remains of the Mastodon that are in the province, and it would be well if we were to carefully investigate every reported case, that may come to our knowledge, of large bones being found anywhere, particularly at a distance from the sea, as at the latter remains of cetaceans are often met with. While the island of Cape Breton naturally suggests

itself as a most promising field for search,—and perhaps, as
some have supposed, the reported lesser glacial erosion there
might be a favourable factor,—yet the whole province should
not be neglected.

A Micmac Indian, known as "Dr. Lone Cloud" or Jerry
Bartlett, informs me that about 1874 a very old Indian woman,
Magdalene Pennall of Sissiboo (Weymouth), Digby county,
informed him that there had then been long known to her
people certain very large rib-bones, which they supposed to
be "whale ribs," on the barrens about two or three miles south-
eastward of Blue Mountain lake, about twenty-five miles from
the sea, in the northeastern part of Yarmouth county, N. S.
The place is a very short distance east of Bloody creek or
brook (a tributory of the Clyde river) and on a trail from that
creek via Long lake, to the head-waters of the Shelburne or
Roseway river to the eastward. On one occasion, Mrs. Pennall
and her husband, Joe (Kophang), just after having left their
canoe on Bloody creek, killed a moose at the spot where the
bones were, and as a thunder shower came on they stood three
of the large ribs against a rock, covered them with the moose-
hide, and so formed a shelter. Some of the ribs which were
on the ground were covered with a thick mantle of moss. Lone
Cloud thinks there may have been some vertebræ there also,
but knew of no other kinds of bones. Once some Indians
carried away one of these big ribs, but as it was very heavy it
was at last dropped, and the superstitious Indians affirmed
that it was afterwards found once more in its original place,
which caused the remains to be regarded with some veneration
by members of the tribe.

The same Indian was also informed by John Jadis, a vener-
able and well-known Indian still living at Enfield, that very
many years ago there were found at the Horne settlement at
the outlet of Grand lake, Hants county, twenty-six miles from
the sea and in the very heart of the province, some large
vertebræ which were thought by the old inhabitants of the

district to be parts of a whale's backbone, and they were used as little stools to sit on. These have long ago disappeared, and the present Hornes know nothing of them. What particularly puzzled the Indian was, how "whale bones" could get to such inland places as the two just mentioned.

I have never seen these so-called whale bones, but one naturally ventures the opinion that possibly they may have been Mastodon remains, and that those traversing our waste-lands, as well as those cultivating surface deposits, should keep a sharp look-out for any such large bones, particularly at a distance from the sea, and should any be discovered some authority's opinion as to their identity should by all means be obtained.

A supposed Mastodon's skull was recently found on the shore of the Bras d'Or lake and was forwarded to the museum of the Provincial Normal College at Truro. This immediately aroused interest, but on examining photographs of it, I identified it as the cranium of a cetacean, the Black Fish (*Globicephalus melas*).

Halifax, N. S.,
    13th May, 1912.

Phenological Observations in Nova Scotia, 1911.—By A. H. MacKay, Ll. D., F. R. S. C., Halifax.

The phenochrons of the ten phenological regions of Nova Scotia were published in the Proceedings of the Royal Society of Canada, from those of 1902 to those of 1909, and in the Transactions of the Nova Scotia Institute of Science up to those of 1904. Phenological dates from a few or more stations were commenced to be published annually in both from the year 1892, including later, phenological dates from observation stations throughout Canada.

The most exact observations have been made through the schools of Nova Scotia, the pupils on their daily way to and from school reporting competitively to the teachers the first "finds." The object at first was the stimulation of Nature Study in the schools. But the multitude of observers every day at work, and the accurate checking of the observations by the teachers, made the school work not only fuller in quantity and more continuous in time, but practically as accurate as those made by scientific observers.

The schedules from each school are sent in by the teachers to the inspectors who transmit them to the Education Office, where they are bound in annual volumes and presented to the Provincial Science Library archives for the use of future students of climate problems. Three hundred or more of the best schedules are thus each year selected for permanent record. This selection has for many years been done by a staff of compilers who compute the phenochrons (average phenological dates) for the subsections of each region, so as to show the effect of the coast line and altitudes in each region.

These sheets of phenochrons are also bound up annually and deposited with the volumes of the fundamental schedules. The system of dating adopted is the annual instead of the usual mensual dates, on account of simplicity in the computation of the phenochrons.

As some of the regional schedules of 1910 have been accidentally misplaced, the general table of regional phenochrons is not yet ready for printing, and may simply be bound up for the archives. The regional table for the calendar year 1911 have been compiled by Mr. John Burris Reid, clerk in the Education office, and is published here rather to advertise the fact that the original local schedules and sub-regional phenochrons are available for any special studies of Nova Scotian phenology. To explain the table, the following instructions to compilers of the "belt" and "region" phenochrons are repeated.

"A province may be divided into its main climatic slopes or regions which may be seldom coterminous with the boundaries of counties. Slopes, especially those to the coast, should be subdivided into belts such as (a) the coast belt, (b) the low inland belt, and (c) the high inland belt.

In Nova Scotia the following regions are marked out, proceeding from north to south, and from east to west, as orderly as possible:

No.	REGIONS OR SLOPES.	BELTS.
1.	Yarmouth and Digby Counties.	(a) Coast, (b) Low Inlands, (c) High Inlands.
2.	Shelburne, Queens and Lunenburg Counties	(a) Coast, (b) Low Inlands, (c) High Inlands.
3.	Annapolis and King's Counties.	(a) South Mts., (b) Annapolis Valley, (c) Cornwallis Valley, (d) North Mts.

No.	REGIONS OR SLOPES.	BELTS.

4. Hants and Colchester, South of
   Cobequid Bay .... (a) Coast, (b) Low Inlands, (c)
   High Inlands.

5. Halifax and Guysboro Counties. (a) Coast, (b) Low Inlands, (c)
   High Inlands.

6. (A) Cobequid Slope to S. (B)
   Chignecto Slope to N. W.... (a) Coast, (b) Inlands.

7. Northumberland Straits Slope,
   (to the North) .... (a) Coast, (b) Low Inlands, (c)
   High Inlands.

8. Richmond and Cape Breton
   Counties .... (a) Coast, (b) Low Inlands, (c)
   High Inlands.

9. Bras d'Or Slope (to S. E.).... (a) Coast, (b) Low Inlands, (c)
   High Inlands.

10. Inverness Slope (to Gulf N. W.). (a) Coast, (b) Low Inlands, (c)
    High Inlands.

[*When the belts* (b) *and* (c)—*Low and High Inlands—are not sufficiently distinct, they may be combined in any "region" into one (belt* b c)—*Inlands. There will then be but two belts to be considered "Coast" and "Inlands."*]
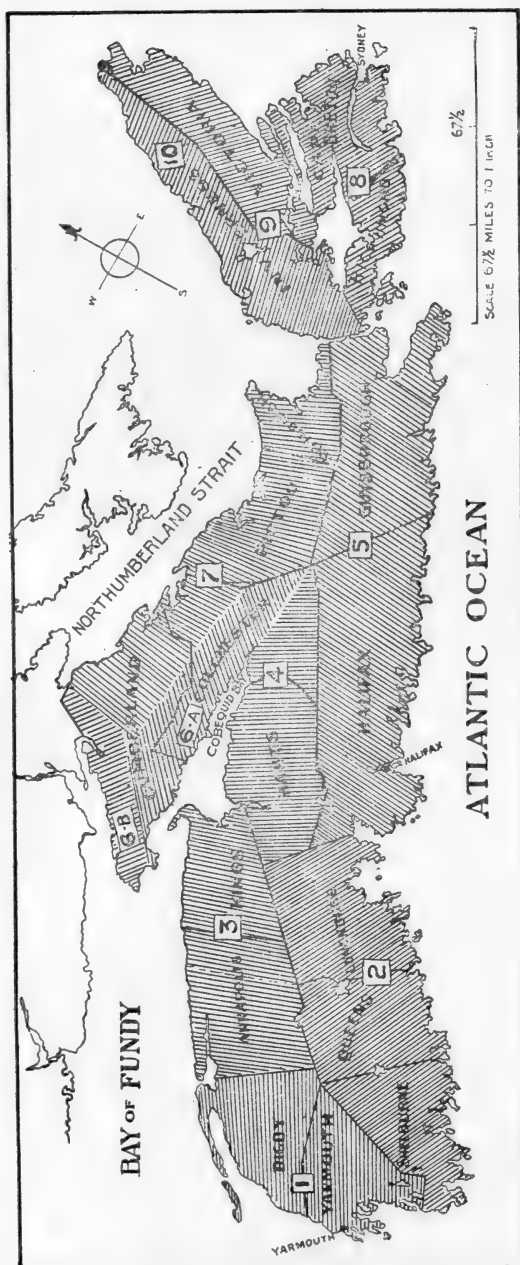
THE TEN PHENOLOGICAL REGIONS OF NOVA SCOTIA.

Averaging Local Phenochrons for "Region" or "Belt" Phenochrons.—If ten or fewer good phenological observation schedules can be selected from those belonging to any given belt, they may be averaged as indicated in the columns within. If there are not ten from each belt, then it may be better to combine two belts, or if necessary, three belts on the form within. In the latter case the average will be the "region" phenochrons. When a full sheet can be made out for each belt, the average of the phenochrons for the three "belts" will give the phenochrons for the "region." Finally, the phenochrons of each of the ten regions will be averaged to find the provincial phenochron for each phenomenon on the list. This will be done by the compiler-in-chief.

There is a convenience in- averaging the dates of ten stations, which accounts for the ten columns for stations in the form* within. When a few dates are not given it may be fair to enter in the blanks* the dates from a similar and neighboring station which is not otherwise utilized for the sheet. Great care should be taken that such observations taken from a schedule not summarized, should be what might have been observed at the station indicated in the heading, and to indicate such a transference the date should be surrounded by a circle with the pen, which would always means that the observation was not made in the station heading the column,* but in a neighbouring one, and was taken from a supernumerary schedule.

Thunder-Storms.—These dates will be entered in their respective columns and opposite the month indicated. They will not be averaged, of course. The number of observation schedules represented in any "region" or general sheet under this head should be noted somewhere on the top margin of the page.

Accuracy.—Care must be exercised in selecting schedules, the observations of which appear to have been carefully made,

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*Footnote on p. 180.

neglecting any which give reason for doubt, when selecting for summation on the form* within. Great care must also be exercised in copying the figures and entering them, so that no slip may occur. Every entry should be checked. One slip may spoil the effect of all the accurate numbers entering into the summation. In like manner great care has to be taken in adding and averaging the figures, and for this purpose every sum should be done twice (once in reverse order), so as to give absolute confidence in the accuracy of the work.

Remarks.—The compiler filling one of these blanks* should keep one copy for himself while sending the other to the compiler-in-chief.

The set of stations on the right under "when becoming common," must be *exactly* the same as on the left, under "when first seen." The compiler can enter explanatory remarks in the blank* below, and should sign each sheet as a guarantee of its correctness. These sheets* will be bound into a volume for each year."

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*These words refer to the ruled and printed blank forms into which the compilers enter the averages, which are finally compiled into the same blank form as exhibited in the following table.

Nomenclature as in GRAY'S or SPOTTON'S MANUAL.

FLOWERING AND OTHER PHENOCHRONS FOR THE PROVINCE OF NOVA SCOTIA, 1911.

[COMPILED FROM ABOUT 300 PUBLIC SCHOOL OBSERVATION SCHEDULES. THE DECIMAL FRACTIONS ARE OMITTED ON ACCOUNT OF THE SMALL SPACE IN THE REGIONAL PHENOCHRONS].

YEAR ENDED DECEMBER, 1911.

Day of the year corresponding to the last day of each month.

Month	Day
Jan.	31
Feb.	59
March	90
April	120
May	151
June	181
July	212
Aug.	243
Sept.	273
Oct.	304
Nov.	334
Dec.	365

For Leap Year add one to each except January.

Regions:
1. Yarmouth and Digby.
2. Shelburne, Queens, and Lunenburg.
3. Annapolis and Kings.
4. Hants and South Colchester.
5. Halifax and Guysboro.
6. South Cobequid Slope (S. Cumb. and Col.).
7. North Cumb., Col., Picton and Antig.
8. Richmond and Cape Breton.
9. Bras d'or Slope (to South East).
10. Inverness Slope (to Gulf N. W.).

WHEN FIRST SEEN.

#	Species	1	2	3	4	5	6	7	8	9	10	Average Dates
1	Alnus incana, Wild	108	108	111	117	113	123	114	122	112	111	114.2
2	Populus tremuloides	96	114	118	116	118	120	121	128	126		120.9
3	Epigæa repens, L	128	104	106	131	121	111	124	119	119	115	112.4
4	Equisetum arvense		129	133	130	135	126	129	143	132		132.3
5	Sanguinaria Canadensis	120	123	133	131	130	126	127	132	128	129	131.6
6	Viola blanda	123	127	124	131	127	129	128	135	131	132	126.8
7	Viola palmata, *cucullata*	118	123	127	135	132	132	130	156	174		130.1
8	Hepatica triloba, etc	125	124	123	135	129	127	128	140	135	118	134.8
9	Acer rubrum	124	125	125	131	129	129	129	135	137	131	128.5
10	Fragaria Virginiana	155	155	128	164	165	156	133	176	164		129.0
11	" " fruit ripe	125	151	134	152	161	131	135	137	137	132	162.4
12	Taraxacum officinale	131	131	134	147	134	134	134	160	127	133	132.1
13	Erythronium Americanum	129		139	137	137	152	131	137	146	133	144.0
14	Coptis trifolia			134	131	133	135	134	146	142	132	134.7
15	Chaytonia Caroliniana			139	138	142	137	136	169	169	135	134.1
16	Nepeta Glechoma	145	183	131	138	139	141	133	144	144		141.1
17	Amelanchier Canadensis	135	130	139	138	181	131					136.8
18	" " fruit ripe		178	177	196	181						183.3

WHEN BECOMING COMMON.

#	Species	Average Dates	1	2	3	4	5	6	7	8	9	10
1	Alnus incana, Wild	120.5	118	118	118	127	118	132	118	126	119	114
2	Populus tremuloides	126.9		111	122	122	122	124	129	135	132	121
3	Epigæa repens, L	129.9	135	135	130	137	140	140	124	130	127	121
4	Equisetum arvense	137.7		128	128	139	137	133	132	150	134	131
5	Sanguinaria Canadensis	135.4	128	131	135	135	137	133	132	137	134	131
6	Viola blanda	132.8	130	128	130	139	137	134	135	141	138	133
7	Viola palmata, *cucullata*	135.8	123	131	133	111	139	130	153	147	183	125
8	Hepatica triloba, etc	133.3	133	131	129	134	132	130	153	147	142	134
9	Acer rubrum	137.1	169	131	133	173	138	139	169	183	181	131
10	Fragaria Virginiana	171.7	169	135	134	141	132	130	139	142	145	167
11	" " fruit ripe	138.2	135	135	138	153	140	141	139	141	157	133
12	Taraxacum officinale	149.2	136	136	141	148	140	143	139	164	145	141
13	Erythronium Americanum	140.4		138	140	142	139	143	139	145	139	139
14	Coptis trifolia	139.8		134	134	142	148	148	139	145	148	140
15	Chaytonia Caroliniana	146.7	152	181	134	143	143	143	129	174	149	136
16	Nepeta Glechoma	142.1	141	141	180	143	143	146	137	150	148	
17	Amelanchier Canadensis	184.3			189		143	142	141	174	152	141

FLOWERING AND OTHER PHENOCHRONS FOR THE PROVINCE OF NOVA SCOTIA, 1911—(Continued).

YEAR ENDING DECEMBER, 1911.

Day of the year corresponding to the last day of the month,

Jan.	31
Feb.	59
March	90
April	120
May	151
June	181
July	212
Aug.	243
Sept.	273
Oct.	304
Nov.	334
Dec.	365

For Leap Year add one to each except January.

WHEN FIRST SEEN.

No.	Species	Average Dates	1. Yarmouth and Digby	2. Shelburne, Queens, Lunenburg	3. Annapolis and Kings	4. Hants and South Colchester	5. Halifax and Guysboro	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Picton and Antig.	8. Richmond and Cape Breton	9. Bras d'or Slope (to South East)	10. Inverness slope (to Gulf, N.W.)
19	Prunus Pennsylvanica	140.6	135	134	133	142	142	138	137	151	150	140
20	Vaccinium Can. and Penn.	212.6	195	195	167	222	229	229	245	152	218	
21	" fruit ripe	139.5	180	131	182	174	161	151	150	216	147	131
22	Ranunculus acris	187.0	145	177	181	174	157	157	156	163	219	156
23	R. repens	150.9	144	151	144	149	151	138	144	163	161	135
24	Trill. erythrocarpum	155.3	144	151	150	153	146	138	157		147	143
25	Rhododendron Rhodora	143.0	137	138	145	141	146	145	140	149	153	158
26	Cornus Canadensis	142.3	146	144	145	149	149	163	146	158	225	
27	" fruit ripe	149.7		193								
28	Trientalis Americana	197.5	143	143	137	146	149	143	146	157	157	139
29	Clintonia borealis	146.1	145	149	148	146	157	148	152		154	
30	Calla palustris	151.6	147	152	148	154	163	163	154	166	157	151
31	Cypripedium acaule	157.6	149	150	149	154	161	151	153	164	169	151
32	Sisyrinchium angustifolium	156.0	150	150	146	154	159	157	156	166	172	157
33	Linnea borealis	156.4	159	153	159	161	166	157	161	177	170	157
34	Kalmia glauca	161.3	149	149	144	151	158	144	144	151	158	
35	Kalmia angustifolia	160.5	158	155	151	158	158	155	162	162		158
36	Crataegus oxyacantha	157.9	152	149	147	152	151	159	154	155	162	
37	Crataegus coccinea, etc.	153.9	152	147	146	148	150	151	147	138	166	166
38	Iris versicolor	152.1	155	156	156	162	168	165	162	175	170	158
39		163.0										

WHEN BECOMING COMMON.

No.	Average Dates	1. Yarmouth and Digby	2. Shelburne, Queens, and Lunenburg	3. Annapolis and Kings	4. Hants and South Colchester	5. Halifax and Guysboro	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Picton and Antig.	8. Richmond and Cape Breton	9. Bras d'or Slope (to South East)	10. Inverness slope (to Gulf, N.W.)
19	146.1	141	138	137	145	147	144	141	157	156	142
20	232.4		208		233		240	255		226	
21	146.2	143	140	140	148	149	146	145	158	154	136
22	202.7		215	213	214		164	155	222	235	
23	157.7	151	152	150	156	160	164	155	164	164	165
24	159.8	149	156	155	159	161	157	155	168	168	
25	149.8	144	149	145	150	152	145	160		153	147
26	147.0	152	142	143	146	155	152	148	164	161	167
27	156.2		150	150	154		182	155		174	
28	212.0		207		231						
29	151.7	147	148	140	151	153	152	149	163	158	148
30	156.9	152	154	151	155	163	152	154	170	160	163
31	162.5	154	159	155	160	167	163	159	170	163	174
32	161.7	157	151	152	166	163	139	158	172	177	177
33	162.4	166	160	151	159	166	159	160	179	177	174
34	168.5	138	154	162	156	170	168	165	167		
35	157.9	164	161	161	166	161	149	149	168	160	190
36	163.9	164	154	161	155	162	156	167	168	163	166
37	160.1	159	152	151	150	157	169	163	170		179
38	156.2	159	152	150	150	161	156	151	170	173	
39	168.3	161	162	162	163	172	169	166	179	174	165

No.		
40	Chrysanthemum Leucanthemum	
41	Nuphar advena	
42	Rubus strigosus	
43	" " fruit ripe	
44	Rhinanthus Crista-galli	
45	Rubus villosus fruit ripe	
46		
47	Sarracenia purpurea	
48	Brunella vulgaris	
49	Rosa lucida	
50	Leontodon autumnale	
51	Linaria vulgaris	
52	Trees appear green	
53	Ribes rubrum (cultivated)	
54	" " (fruit ripe)	
55	R. nigrum (cultivated)	
56	" " fruit ripe	
57	Prunus Cerasus... fruit ripe	
58		
59	Prunus domestica	
60	Pyrus Malus	
61	Syringa vulgaris	
62	Trifolium repens	
63	Trifolium pratense	
64	Phleum pratense	
65	Solanum tuberosum	
66	Ploughing first of season	
67	Sowing	
68	Potato planting	
69	Sheep-shearing	
70	Hay-cutting	
71	Grain-cutting	
72	Potato-digging	
73a	Opening of rivers	
73b	Opening of lakes	
74a	Last snow to whiten ground	
74b	" to fly in air	
75a	Last spring frost—hard	
75b	" " —hoar	
76a	Water in streams—high	
76b	" " low	
77a	First autumn frost, hoar	
77b	" " hard	
78a	First snow to fly in air	
78b	" whiten ground	
79a	Closing of lakes	
79b	" rivers	

FLOWERING AND OTHER PHENOCHRONS FOR THE PROVINCE OF NOVA SCOTIA, 1911—(Continued).

YEAR ENDING DECEMBER, 1911.

Day of the year corresponding to the last day of the month.

Month	Day	Month	Day
Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	171	Dec	365

For Leap Year add one to each except January.

WHEN FIRST SEEN — Region

#	Species	1. Yarmouth and Digby	2. Shelburne, Queens, and Lunenburg	3. Annapolis and Kings	4. Hants and South Colchester	5. Halifax and Guysboro	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Picton and Antig.	8. Richmond and Cape Breton	9. Bras d'or Slope (to South East)	10. Inverness slope (to Gulf, N.W.)	Average Dates
81a	Wild ducks migrating, N	182	81	89	93	89	77	81	91	103	104	89.2
81b	" " " S	300	86	326	312	291	273	295	281	294	362	306.2
82a	" geese " N	83	307	79	77	79	77	81	76	97		82.3
82b	" " " S	312	85	312	323	306	262	286		287		299.6
83	Melospiza fasciata, North	84	81	85	85	95	113	91	118	95	100	94.9
84	Turdus migratorius "	81	88	82	88	91	89	98	93	98		87.3
85	Junco hiemalis "	83	83	94	88	77	128	92	97	129		91.9
86	Actitis macularia "	107	107	138	120	127		152			128	128.8
87	Sturnella magna "		127	131	125	127	128	127	172	125		135.0
88	Dendroeca coronata "	125	127	131	130	120	133	139	133	133		127.6
89	Ceryle Alcyon "	109	133	140	141	127	135	143	140	140		132.4
90	D. aestiva "	127	119	131	136	141	14	116	175	121		140.8
91	Zonotrichia alba "	139	115	136	142	144	13	146	140	156	110	126.0
92	Trochilus Colubris "	138	138	138	127	127	128	127	178	111	108	148.3
93	Tyrannus Carolinensis "	132	156	130	139	143	131	132		142	112	129.8
94	Dolychonyx oryzivorus "	139	122	133	151	152	139	141	167	111		139.9
95	Spinis tristis "	138	148	188	145	124	135	160	177			144.1
96	Setophaga ruticilla "			106	150	124	142		143			149.3
97	Ampelis cedrorum "					138	132			149	110	136.6
98	Chordeiles Virginianus "	131	131	134	151	116	132	115	154	112	108	133.7
99	First piping of frogs "	101	107	110	145	120	119	115	121	112	112	112.5
00	First appearance, snakes "	107	113	118	123	116	126	128	118	121		119.0

WHEN BECOMING COMMON — Region

1. Yarmouth and Digby	2. Shelburne, Queens, and Lunenburg	3. Annapolis and Kings	4. Hants and South Colchester	5. Halifax and Guysboro	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Picton and Antig.	8. Richmond and Cape Breton	9. Bras d'or Slope (to South East)	10. Inverness slope (to Gulf, N.W.)	Average Dates

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1911.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (to South East).	10. Inverness Slope (to Gulf N. W.)	Total reports of Thunderstorms for year 1911.
						30				30
					81					81
86										86
	87		87						87	87[3]
	89[6]	89[3]	89[9]	89[4]		89				89[23]
	90[2]	90[10]	90[4]	90[2]	90	90				90[20]
						92				92
					96	96[4]				96[5]
						97[7]	97		97	97[9]
							98			98
					99					99
				101						101
		106[2]	106[4]		106[5]	106				106[12]
							109			109
				114						114
							116			116
						118				118
120	120					120[3]				120[5]
121[3]	121	121			121					121[6]
				122			122			122[2]
					125					125
						126				126
	129			129	129	129				129[4]
130						130				130[2]
131						131	131			131[3]
	132[7]	132[7]	132	132[2]	132[3]	132[6]	132[3]			132[29]
133	133	133[5]	133[3]		133	133[12]	133[2]	133		133[26]
			134		134	134	134			134[3]
		135								135
		136		136						136[2]
		137			137					137[2]
	139[2]				139					139[3]
	140	140[2]		140						140[4]
141[2]	141[2]	141[2]	141[5]	141[10]	141[7]	141[10]	141[2]	141		141[41]
142	142[16]	142[6]	142[5]	142[2]	142	142[7]				142[38]
	144	144			144					144[3]
		145								145
				146[2]	146					146[3]
	147					147	147		147	147[4]

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, N. S., 1911—*Continued.*

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (to South East).	10. Inverness Slope (to Gulf N. W.)	Total reports of Thunderstorms for year 1911.
148^8	.....	148^4	.....	148^4	148^5	148^5	148	.....	.....	148^{22}
149^8	149^{18}	149^{16}	149^{10}	149^1	149^7	149^{21}	149^4	149	149	149^{102}
150^8	150^8	150^2	.....	150^{56}	.....	150^4	150^2	....	....	150^{24}
151	151	....	....	151^2	151	151	....	151	....	151^7
.....	.....	152	....	152	.....	.....	.....	152	...	152^8
.....	.....	....	....	.....	153^2	.....	.....	.....	....	153^2_3
.....	154	....	....	154	...	.....	154	.. .	....	154^9
.....	155^{13}	155^2	155^7	155^4	155^2	155	...	....	....	155^2
.....	156^8	156^2	156^{10}	156^{16}	156^3	153	....	.. ..	.....	156^{44}
.....	157	....	.....	.....	157	.....	....	.. ..	.....	157^2
158	.. ...	....	...	....	.. .	.....	.. .	.....	.....	158
160	160	....	....	.....	....	160	.. .	.....	.....	160^3
.....	.. .	.. ..	162	... .	....	....	....	.....	.. ...	162
163^8	163	.....	.....	163	.....	163	163	.....	.. ...	163^7
164^6	164^7	164^7	....	.....	.....	.....	.....	.....	.....	164^{29}
165	165^{12}	165^4	165^6	165^{19}	....	165^2	165^5	165	165^2	165^{52}
.....	166	.....	.....	.....	....	166^2	.....	...	....	166^8
.. ...	167^4	167	.....	167	....	....	167	.....	....	167^7
....	168	... .	.....	168^4	....	.....	168	.....	. ...	168^6
.....	....	....	....	.....	....	169^2	...	.....	...	169^2
.....	170	170^2	....	170^6	170	170^9	170	.....	....	170^{20}
171^2	171^2	171^8	171^{11}	171^{17}	171^2	171^{19}	171^2	171	171	171^{65}
172	172^9_3	172	173^3	172^{14}	172	172^9	172^2	....	172	172^{41}
173^8	173^8_3	....	173^2	173^6	173^2	173	173	.....	.....	173^{18}
174^2	174^3	174^4	174^6	174^{11}	174^7	174	.....	174	.....	174^{85}
.....	....	.....	.....	175^2	....	.....	.....	...	....	175^2
.....	.....	.....	....	.. .	....	177^2	...	...	....	177^2
.. .	.....	184	....	....	184	184	....	....	....	184^8
185	.....	185	.. .	.....	.....	....	....	....	....	185^2
....	.....	.....	....	.. .	.....		....	186	....	186
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.....	.....	.....	....	.. .	.....		....	198	....	198
.....	.....	.....	....	.. .	.....		....	200	... .	200
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....	.....	.. ..	.....	...	....		....	216	.....	216

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, N. S., 1911—*Continued*.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro	6. S. Cobequid Slope (S. Cum. & Col).	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (to South East).	10. Inverness Slope (to Gulf N. W.)	Total reports of Thunderstorms for year 1911.
. . .	. . . . .	. . . .	. . .	. . . . .	. . . . .	. . . . .	. . . . .	217	. . . .	217
. . . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . . .	. . . . .	218	. . . .	218
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. . . .	274⁴	274⁴	274	. . .	274⁴	. . . . .	. . . . .	. . . . .	. . . . .	274¹³
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. . . . .	321	. . . . .	. . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	321
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CLIMATE OF HALIFAX, N. S.*
Meteorological Table (Averages).
Latitude, 44° 39′ north ; Longitude, 63° 36′ west.
Based on official records of THE CANADIAN METEOROLOGICAL SERVICE for
from 20 to 24 years.
Brought down to 31st December, 1911.

MONTH	Mean Barometric Pressure at sea level. 24 years observations.	TEMPERATURE (Fahrenheit).			Mean Relative Humidity. 20 years obsr.	Per cent. of Cloud. 20 years obsr.
		Mean 24 years obsr.	Absolute Highest. 24 years ob	Absolute Lowest. servations		
JANUARY	29.97	24.4	55.2	− 16.0	88	64
FEBRUARY	29.94	23.7	50.2	− 16.9	86	62
MARCH	29.92	31.4	60.0	− 9.0	82	60
APRIL	29.93	39.9	79.2	7.2	78	60
MAY	29.98	49.5	90.4	22.1	79	62
JUNE	29.94	57.8	94 4	31.8	81	63
JULY	29.94	64.9	93.0	32.8	86	62
AUGUST	29.97	64.5	93.1	39.2	87	55
SEPTEMBER	30.05	58.8	88.2	28.7	87	51
OCTOBER	29.98	48.8	85.7	19.0	86	55
NOVEMBER	30.00	39.6	57.2	4.3	85	68
DECEMBER	29 95	29.1	62.0	− 11.2	86	66
YEAR	29.97	44.4	94.4	− 16.9	84	61

Highest barometer on record, 31.03 ins ; date 5th March, 1904.
Lowest   ,,   ,,   ,,   28.55 ,,   ,,   1st April, 1879.
Highest temperature on record, 94 4 ; date, 26th June, 1909.
Lowest   ,,   ,.   ,,   − 16.9 ;   ,,   25th February, 1876.
Greatest precipitation on record, 5.43 ins. ; date 2nd August, 1908.
Average mean temperature, spring months, 40.3.
      ,,   ,,   ,,   summer months, 62.3.

*Published by permission of R. F. Stupart, Esq., Director of the Meteorological
Service, Toronto.

CLIMATE OF HALIFAX, N. S.

Meteorological Table (Averages).

Latitude, 44° 39′ north ; Longitude, 63° 36′ west.

Based on official records of THE CANADIAN METEOROLOGICAL SERVICE for from 20 to 24 years.

Brought down to 31st December, 1911.

WIND.		PRECIPITATION.			Number of Fair Days.	Number of Thunder Storms.	Number of Fogs.
Prevailing Direction. 20 years obsr.	Mean Miles per Hour.	Average Mean. 24 years ob	Heaviest Fall. servations	Number of Days with .01 Precipn. or more. 24 yrs ob.	20 ye	ars observ	ations.
		Inches.	Inches.				
W	12	6.01	10.12	16	15	0	2
W	12	4.71	8.74	13	15	0	1
W	11	5.14	9.88	14	17	0	2
W	11	4.67	8.38	14	16	0	3
W	9	3.78	6.30	13	18	1	5
W	8	3.81	6.97	13	17	1	4
W	7	3.66	8.73	12	19	1	5
W	6	4.59	10.66	13	18	1	3
W	7	4.10	12.10	11	19	1	2
W	9	5.55	15.02	13	18	0	1
N.W.	10	5.87	10.25	15	15	0	1
N.W.	10	5.51	10.25	14	17	0	1
W	9	57.40	15.02	161	204	5	30

Average mean temperature, autumn months, 49.1.

,,   ,,   ,,   winter months, 25.8.

Warmest month of year, July.

Coldest   ,,   ,,   February.

Most precipitation, month of January.

Least   ,,   ,,   July.

Most cloud, month of November.

Least ,,   ,,   September.

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ERRATA

Page 62, seven lines from bottom, for C_{12} read C_{72}.

" 64, nineteen lines from bottom, for $K_3Fe\,(CN)_6$ read $K_4Fe\,(CN)_6$.

" 65, eight lines lines from top, for Turnbull's read Prussian.

" 137, eight lines from bottom, for while read whole.

" 143, two lines from top, for *expotential* read *exponential*.

TRANSACTIONS

Nova Scotian Institute of Science.

ON THE ELECTRICAL RESISTANCE OF ACETIC ACID IN THE
SOLID AND LIQUID PHASES.—BY J. H. L. JOHNSTONE,
B. Sc., Dalhousie University, Halifax, N. S.*

In a previous paper[1] the writer published some results on
the electrical resistance of ice, showing how it varied with the
temperature. Its temperature-coefficient was found to be
unexpectedly large and a further investigation of this point
was thought desirable.

As it had been difficult to obtain satisfactory regulation
of temperature below 0° C, it was decided to choose for the
present investigation some substance with a melting-point so
high, that with the substance in the solid state, the temper-
ature could be regulated in a thermostat. Acetic acid appeared
to fulfil these conditions; and it can be easily obtained in a
comparatively pure state.

The method of measurement used in the previous inves-
tigation was inconvenient. It was also felt to be unsatisfac-
tory as it was a direct current method and so introduced the
danger of polarization effects. It seemed desirable there-
fore to obtain some alternating current method.

THE OBJECTS OF THIS WORK WERE:—

1.   To determine a satisfactory method for the measurement of large electrolytic resistances.

2.   To measure the electrical resistance of acetic acid in the solid and liquid phases at different temperatures and to find the causes of the variations which occur.

3.   To determine the effect of small quantities of water on the resistance.

In the measurement of electrolytic resistances the effects of the electro-motive force of polarization are in general quite marked. This polarizing effect consists of two parts; one of which is a function of the current, $f(i)$, and is in fact, a variable resistance, increasing with time due to the deposition of gas on the electrodes. The other part, e, is a true polarization e. m. f. which is independent of the value of the current passing thru the electrolytic cell. It seldom amounts to more than 1 or 2 volts. Any alternating current method should practically eliminate both of these effects.

Using the well known method of Kohlrausch, resistances greater than 10^5 ohms, cannot be measured with any great accuracy. For satisfactory measurements of resistances ranging between 10^4 and 10^8 ohms another alternating current "bridge" method is suitable. In this method the telephone or galvanometer of the Kohlrausch apparatus is replaced by an electrometer and two of the resistances by capacities.

To measure resistances greater than 10^8 ohms, a direct current method may be used. The $f(i)$ term of the polarization effect will be very small as compared with the total resistance because the current flowing thru the cell will be minute, and furthermore as the applied e. m. f. is large the "e" term will be a small fraction of the total e. m. f. Using a sensitive galvanometer, connected as in figure 1, resistances ranging from 10^8 to 10^{10} ohms may be conveniently measured.

FIG. 1
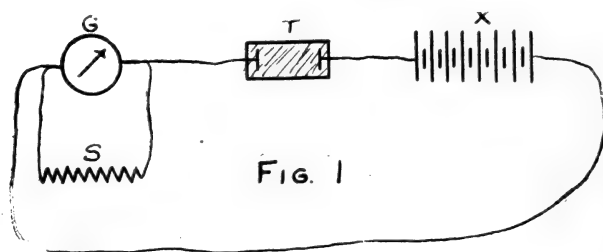
For greater values of resistance than 10^{10} ohms, the electrometer may be substituted for the galvanometer and the apparatus connected as in figure 2.
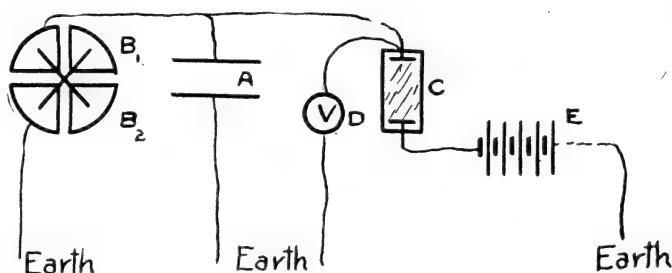
Fig 2

The A. C. Bridge method[1] referred to, was used considerably in this work. It consists of a network of two resistances and two condensers connected with a source of alternating current, (110V), as shown in figure 3. The electrometer was of the *Dolezalek* type but was fitted with an aluminium needle.

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1 Journal de Physique ; Series 5, III, Jan. '13.
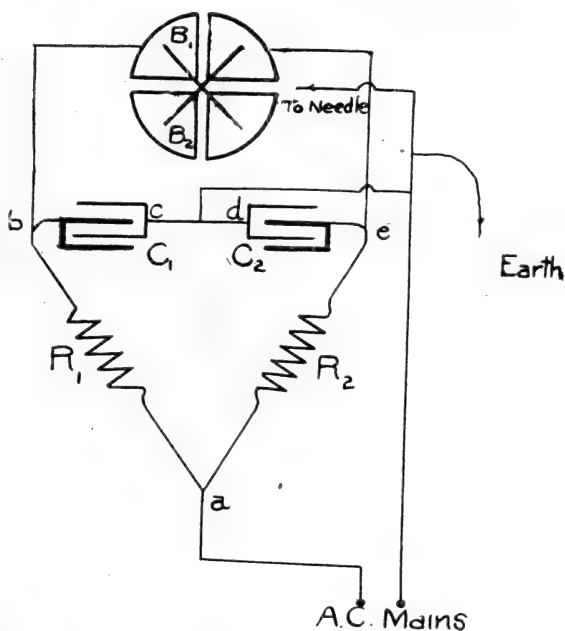
Fig 3

In fig. 3:—

B_1 and B_2 are two quadrants of the electrometer.

C_1 and C_2 are two capacities.

R_1 $\equiv$ an adjustable known resistance.

R_2 $\equiv$ the unknown resistance.

A. C. $\equiv$ terminals of A. C. circuit.

Applying Kirchoff's second law to the circuit.

$$I_1 R_1 \text{ Sin. } \omega t - \frac{I_1}{\omega C_1} \text{ Cos. } \omega t$$

$$= I_2 R_2 \text{ Sin. } (\omega t + \Phi) - \frac{I_2}{\omega C_2} (\text{Cos. } \omega t + \Phi)$$

where I_1 is the maximum current flowing in branch ac.

I_2 "   "   "   "   " ad.

At the instant t, the difference in potential between the two pairs of quadrants is:

$$\frac{I_1}{\omega C_1} \text{ Cos. } \omega t - \frac{I_2}{\omega C_2} \text{ Cos. } (\omega t + \Phi).$$

If $\Phi = 0$ and if the above potential difference be zero, then there will be no deflection of the electrometer needle. Then:

$$\frac{I_1}{I_2} = \frac{C_1}{C_2}$$

that is, $C_1 R_1 = C_2 R_2$

which is the condition for no deflection. Hence if C_1, R_1 and C_2 be so chosen that with a given R_2, no deflection of the electrometer results, it is possible from the above equation to obtain the value of R_2. It is well to remark, that the most sensitive conditions for a balance exist when the reactances of condensers C_1 and C_2 are respectively equal to the resistances R_1 and R_2. In practice if the ratios $\dfrac{C_1}{R_1}$ and $\dfrac{C_2}{R_2}$ are each between 5 and $\frac{1}{5}$ comparatively good working conditions exist. This method is given in some detail, as it may be set up with ease and it will give very satisfactory results. Furthermore, it does not involve any knowledge regarding the absolute value of the capacities. It is the writer's belief that it deserves more general attention than it has hitherto received.

A standard $\frac{1}{3}$ M. F. condenser, manufactured by Leeds and Northrup, was used for capacity C_1.

The reactance of this condenser is 8000, approx., for a 60 cycle E. M. F. Four adjustable resistance boxes, manufactured by the same firm and having a combined resistance of 40,000 ohms were used for R_1. The values of R_2, which were measured by this method, ranged from 10^5 to 10^8 ohms and as considerable accuracy was desirable, it was necessary to manufacture three capacities having approximate reactance values of 10^6, 10^7 and 10^8 respectively. Two mica condensers

and a cylindrical condenser were made and their capacities were determined as follows:

If C_1, R_1 and R_2 be known, C_2 may be accurately measured, provided the condition for sensitivity be adhered to. A known resistance as great as 10^6 ohms was necessary for the calibration of the smallest capacity. A subdivided megohm was not obtainable, so three *Hittorf*[1] resistances were constructed. This type of resistance is non-polarizable and is made by filling a glass tube, fitted with Cadmium electrodes, with a 10% solution of cadmium iodide in amyl alcohol. The tube was then sealed off and placed in a larger test-tube filled with oil. Leads were then soldered to the electrodes and passed thru a cork, which closed the tube. (see figure 4).
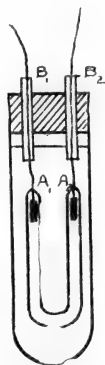
Fig. 4

The $\frac{1}{3}$ M. F. condenser was used as capacity C_1 in the network, thru-out the work.

I   Making $C_2 \equiv .05$ M. F. of a "L and N" subdivided condenser,

  and $R_1 \equiv 3000$ ohms,

    R_2 was adjusted for a balance

    and C_2 was obtained in terms of C_1.

II   Making $C_2 \equiv .05$ M. F.

    and $R_2 \equiv$ No. 1 resistance,

  then R_1 was adjusted for a balance,

  and   No. I resistance was obtained.

III Making $C_2 \equiv$ Mica condenser No. I,

  and $R_2 \equiv$ No. I resistance,

  then R_1 was adjusted,

  and   No. I capacity was obtained.

IV Making $C_2 \equiv$ No. I condenser,

    No. 2 resistance was determined in a similar way.

V   Making $C_2 \equiv$ No. I condenser,

    No. 2 capacity was measured.

---

1 Stewart and Gee, Pract. Physics, Vol. II, pp. 494.

VI Making $C_2 \equiv$ No. 2 condenser,
          No. 3 resistance was measured.
VII Making $C_2 \equiv$ No. 3 condenser,
          No. 3 condenser was measured.

Table I gives the values obtained for the different condensers and resistances. The above series of measurements were made every few days and it was found that the capacities remained remarkably constant, never showing variations greater than 1%.

To find if this method was reliable, the resistances were measured by a direct current method, (see fig. 1), and a very good agreement was found to exist in the two methods. These measurements were made when the tubes had remained in a thermostat for at least 15 minutes. The thremostat consisted of an inner and outer vessel. The outer was constructed so that cold water could be used to circulate about the inside vessel. A heating coil was placed in the latter and using electromagnetic regulation, temperatures ranging from 10 degrees above room temp., to 10 degrees below could be maintained to the tenth part of a degree.

TABLE No. 1.

C_1	R_1	C_2	R_2	Quantity Measured.
$\frac{1}{8}$	3000	.05 M.F.	20494	.05 M. F. = .0487 M. F.
$\frac{1}{8}$	26440	.0487 M.F.	R No. 1	Res. No. 1 = 1.81×10^5 o h m s
$\frac{1}{8}$	4225	C. No. 1	No. 1	Cond. No. 1 = .00783 M. F.
$\frac{1}{8}$	16970	No. 1	No. 2	Res. No. 2 = 7.22×10^5
$\frac{1}{8}$	3170	No. 2	No. 2	Cond. No. 2 = .00146
$\frac{1}{8}$	36220	No. 2	No. 3	Res. No. 3 @ 9° C.= 8.27×10^6
$\frac{1}{8}$	5930	No. 3	No. 3	Cond. No. 3 = .000238

Bakers' acetic acid, (99.55% guaranteed), was used. To eliminate water the acid was fractionally frozen and the mother liquor was then poured off. The resistance of a sample was measured after each separation and it was found
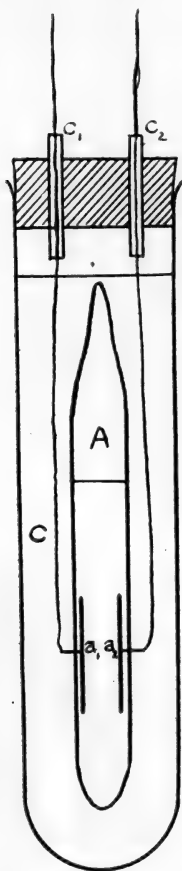
Fig. 5

that the specific resistance increased greatly after each freezing. The greatest number of freezings attempted in any one case was five. With more freezings, a purer sample could, no doubt, be obtained. However there is a limit to the purity obtainable in this manner as you can't prevent the absorption of moisture from the air: and there is also some dissociation. It was thought that the traces of water might be eliminated by adding acetic anhydride (Kahlbaum's C. P.) to the acid. This was tried but it was found that the specific conductivity of the anhydride was greater than that of the acid. Traces of $HCl.$ were afterwards found in the anhydride, which would account for its conductivity.

The resistance vessel, A, (see figure 5), was blown from glass tubing of 0 .7 cm. bore and mane about 12cm. long Into the tube were sealed two platinum electrodes, a_1 and a_2, each of which had an area of about 2 sq. cm. and a chromicsulphuric acid cleaning solution was used. $NaOH$ was then used and finally alcohol to remove grease etc. After washing many times with distilled water, the vessel was dried carefully. To ensure the removal of as much moisture as *possible from the glass*, the tube was connected to a mercury pump and heated to about 160° C in an oil bath for several hours. The pump was exhausted at intervals over a period of two days.

The "cell constant" was determined by measuring the resistance of a $\frac{1}{50}$ N. solution of Kcl on a *Kohlrausch bridge*[1] The tube was then sealed off and suspended in a test tube filled with oil, which was placed in the thermostat. On account of capacity effects it is essential that the thermostat be well earthed.

---

[1] Kohlrausch, F., Physico. Chem. Measurements.

Measurements of the resistance of sample I were made at different temperatures ranging from —7°C. to the melting point. It was found possible to supercool to temperatures as low as 0°C with comparative ease, so measurements were made in the liquid phase at temperatures ranging from 25°C to 0°C.

TABLE 2.

Sample 1. $\approx$ Cell Constant 0.166 $\approx$ M. P. 15.9° C.		
TEMP.	STATE.	SP. RESISTANCE.
—.7°C.	Solid	7.48×10^6
+.6.0	"	7.95×10^6
8.0	"	9.25×10^6
9.5	"	1.10×10^7
10.5	"	1.27×10^7
12.0	"	1.66×10^7
12.9	"	2.01×10^7
14.0	"	2.48×10^7
15.	"	2.76×10^7
15.0	"	2.79×10^7
15.9	"	2.95×10^7
16.0	Liquefying	2.91×10^7
15.9	"	2.62×10^7
17.2	"	2.29×10^7
16.5	"	1.53×10^7
16.5	"	1.37×10^7
18.0	"	1.23×10^7
27.0	Liquid	7.48×10^6
24.9	"	8.24×10^6
23.	"	8.83×10^6
20.9	"	9.72×10^6
18.9	"	1.05×10^7
14.8	"	1.27×10^7
13.0	"	1.39×10^7
10.0	"	1.61×10^7
7.3	"	1.85×10^7
—80°C.	Solid	1.02×10^{13}

In table 2 are given values of the specific resistance for sample I, in the liquid and solid phases at temperatures ranging from 27°C to —7°C. Curve 1 shows how the specific resistance in each phase varies with the temperature. Starting at the point, c, on curve 1, the resistance at first decreases very slowly with rising temperature, then it begins to in-

crease slowly and then with great rapidity until the temperature has risen to the melting point, *d*.   Liquefaction then begins and the resistance decreases very irregularly until finally the liquid phase alone exists in the tube, and the point *f*, is reached.   It is well to state here, that the points on the curve between the eutectic temperature and the melting point, really do not represent the specific resistance of the solid phase, but the resistance of the tube multiplied by the cell constant.   The specific resistance in the liquid phase increases with falling temperature.   This is indicated by the part of the curve, *e a c*, which is quite normal as was to be expected.   It is seen that there exists a point, *a*, at which the specific resistance in the liquid phase is equal to the so called specific resistance in the solid phase at the same temperature. This point was not found to exist in the case of acids which had been more carefully purified.

CURVE 1   SAMPLE NO. 1

TEMPERATURE

SPECIFIC RESISTANCE
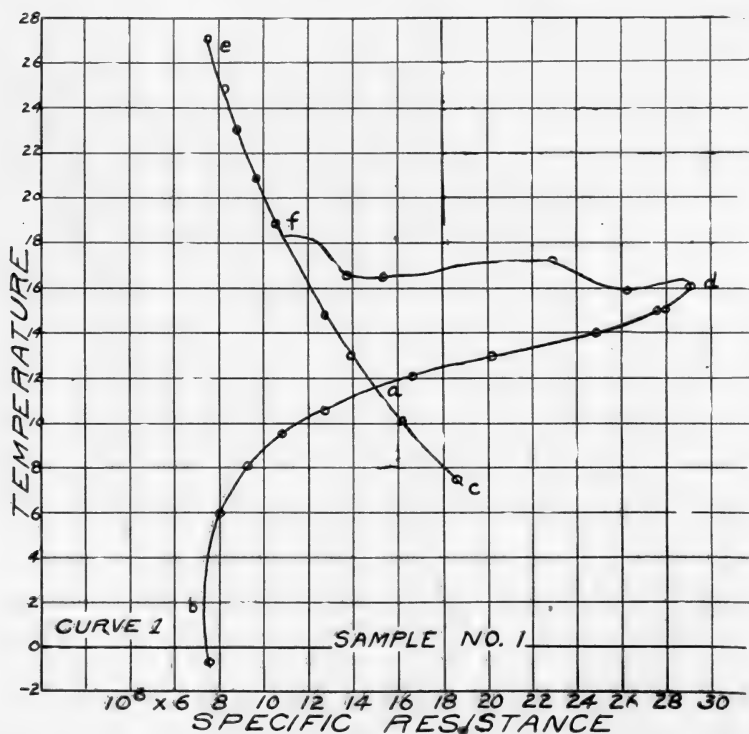
It was found that the specific resistance of the samples used, changed considerably with time and according to the previous history of the tube. This is to be expected, because, the action of the acid on the glass tube will result in the addition of impurities, which will continually decrease the value of such a high resistance as is being dealt with.

The change in resistance of the solid acid with change in temperature is evidently not a true temperature coefficient. It is due in a large part to three factors which are functions of the temperature.

There exists in the tube what may be regarded as a solution of a minute quantity of water in the acetic acid as solvent. As the temperature is lowered the acid gradually crystallizes out, with the result that the freezing point of the liquid portion is gradually lowered and the concentration of the water in the acetic acid is increased. Now the specific resistance of the liquid portion decreases on account of the increasing concentration of water. On the other hand, the effective cross section of the liquid between the electrodes gradually decreases and as a result the specific resistance tends to increase. Thirdly, the resistance tends to increase with decreasing temperature because of a true temperature effect. Examining the curve it is evident that the concentration factor is predominant above $0°C$. This is to be expected as the increase in the concentration of the water in the solution part of the mixture, will be very rapid at first but will gradually decrease. The effect of the second factor, at temperatures near the melting point, will be small compared to the effect of the first factor. With decreasing temp., the volume of the liquid decreases more rapidly and so the second factor will have a gradually increasing effect until finally a temperature is reached when this effect will be equal and opposite to the effect of the first factor. At this point the curve bends and with lower temperatures the second factor is the predominant one, the resistance increasing with

decreasing temperature. The true temperature effect is to make the resistance increase with decreasing temperature, but as the temperature coefficient of this liquid is small, the shape of the curve is not materially affected by this factor.

From the temperature of the bending point, down to the eutectic point, the resistance increases with the decreasing temperature. At the eutectic point, $(-26.55°C)^1$, the solution of water in acetic acid suddenly becomes solid, this mixture containing 59% of solid acid and 41% of ice. A considerable change in the resistance of the tube might be expected to occur at this temperature, and as the temp. is further decreased, the solid mixture should be found to have a true temperature coefficient.

To verify the last supposition, the resistance tube was surrounded by solid carbon dioxide and a temperature of $—80°C^2$ was finally obtained. This was measured by means of a thermocouple placed in the oil bath. As the temp. decreased rapidly it was noted that at some temperature between $—25°$ and $—30°C$ the resistance suddenly increased from approx. 8×10^8 to a value impossible to measure in the "network"· The tube was then connected with an electrometer and condenser, as shown in figure 2. When the temperature of the resistance tube became equal to the temp. of the surrounding solid CO_2, $-80°C$, an E. M. F. was applied and the current passing thru the acetic acid was measured by the electrometer. The specific resistance of sample I was found equal to 1.00×10^{13} @ $-80°C$. Another sample No. 2, somewhat purer than No. I, was measured in a different tube @ $-80°C$ and had a value of 9.92×10^{12}. Sample 2 was removed from the surrounding CO_2 and placed in a Dewar bulb. As the tube heated, resistance measurements were made at intervals, the thermocouple being read at the instant an electrometer

1 Dahms, Wied. Ann 60, 123, 1897.
2 Landolt und Bornstein, Tabellen page 76.

reading was made. In this manner values of the resistance at temperatures ranging from −80° to −47°C were obtained. Above −46°C the resistance was such that it was impossible to use the electrometer as a current measurer, so it was replaced by a *D'Arsonval* galvanometer. This instrument had a sensitivity of 3.52 x 10^9 amperes for one scale division and a resistance of 1900 ohms at room temperature. As the specific resistance of sample 2 varies from 9.92 x 10^{12} @ −80°C to 2.67 x 10^7 @ + 24°C, it is impracticable to plot these values by the direct method, so in curve No. 2, the logarithms of the specific resistance are shown plotted with the temperatures.
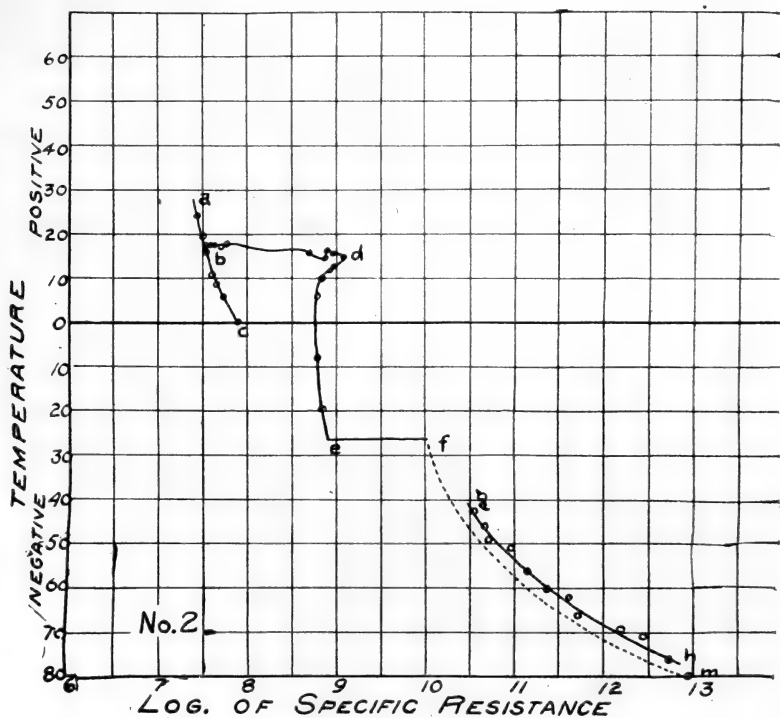
As the thermocouple indicates the temperature of the oil bath, the actual value of the temp. of the acetic acid, corres-

ponding to a particular electrometer reading will be lower than this.   However the true temp. resistance curve shown as the dotted line, drawn from m to f, parallel to $h.g.$ The part of the curve ef indicates clearly the discontinuity in resistance at the eutectic point; it shows that when $-26.55°C$ is reached the resistance of sample 2, changes suddenly from 10^{10} to 8.8×10^8; this change being due to the solidification of the liquid portion between the electrodes.

When the temperature reaches $15°C$, melting of the substance was apparent and the specific resistance decreases very rapidly from 1.27×10^9 to 3.52×10^7 @ $17.5°C$, when liquefaction is complete.   The part of the curve ac, shows the variation of the specific resistance with temp. in the liquid phase.   Values of the specific resistance in the solid and liquid phases of sample No. 2, are given in table 3.

TABLE 3.

Sample 2 = Cell. const. $\equiv$ 4.8 $\approx$ M. P. $\equiv$ 16.4° C.

TEMP.	STATE.	SP. RESISTANCE.
24.0	Liquid	2.67×10^7
19.4	"	3.22×10^7
17.8	"	3.34×10^7
15.7	"	3.60×10^7
10.8	"	4.48×10^7
6.0	"	5.55×10^7
0.	"	7.55×10^7
−19.9	Solid	6.48×10^8
− 8.0	"	6.14×10^8
+ 6.8	"	5.55×10^8
9.8	"	6.86×10^8
11.8	"	8.57×10^8
12.2	"	9.64×10^8
14.8	"	1.27×10^9
13.4	"	1.07×10^9
15.5	Melting	5.16×10^8
17.4	"	6.23×10^7
17.5	"	4.40×10^7
17.5	"	3.65×10^7
17.5	Liquid	3.65×10^7
−80	Solid	9.90×10^{12}
−79.1	"	5.55×10^{12}
−74	"	2.82×10^{12}
−73	"	1.51×10^{12}
−69	"	5.45×10^{11}
−65	"	4.19×10^{11}
−63	"	2.41×10^{11}
−59	"	1.45×10^{11}
−54	"	9.26×10^{10}
−52	"	5.50×10^{10}
−46	"	3.55×10^{10}

At temperatures below the eutectic point no liquid exists between the electrodes and as the amount of ice present is very small in comparison with the acetic acid (solid); there should exist a true temperature coefficient of resistance for the solid acid. Defining this as $\dfrac{1}{R_t} \dfrac{d\,R_t}{d\,T}$ it can be determined from the curve 2, by graphical methods and it is found to vary from 0.3 @ —43°C to 0.25 @ –70°C. The writer[1] found the temp. coeff. of ice to vary from 0.6 @ –2° to 0.12 at –12° and with lower temperatures it increases in value. It thus appears that solid acetic acid is like ice in that it has a very great temperature coefficient of resistance. The temp. coeff. for sample 2 in the liquid phase was calculated in a similar manner and found equal to 0.04 @ 14°C.

To determine the effect of adding considerable quantities of water to the acid, the tube was filled with a 2% solution of water in acetic acid, (sample No. 3), and measurements were made at different temperatures.

A comparison of the specific resistance, temp. coeff. and the melting points for samples 1, 2 and 3 is given in table 4.

TABLE 4.

SAMPLE.	STATE.	M. P.	TEMP.	RES. SP.	TEMP.-COEFF.
1	Liquid	15.9	14° c.	1.3×10^7	.04
2	"	16.4	14	3.8×10^7	.04
3	"	13.2	14	1.2×10^6	.03
1	Solid		12	1.7×10^7	
2	"		12	8.9×10^8	
3	"		12	$2.2 \times 1.^6$	
1	"		−80	1.0×10^{13}	25
2	"		−80	9.9×10^{12}	
3	"		−80	8.4×10^{11}	

[1] Trans. N. S. Ins. of Sc. XIII., part 2, page 143.

The evidence appears to be conclusive, that at temperatures above the eutectic, practically all the current passing thru the acid is conducted by the liquid portion of the mixture between the electrodes. So the term, *specific resistance of the solid at temperatures above the eutectic* is meaningless, and the values obtained for the specific resistance and plotted on curves 1 and 2 merely indicate the resistance of thin columns of the solution of acid and water between the electrodes, multiplied by the cell constant. To obtain a true value for the specific resistance of the solid acetic acid, the temperature must be kept below the eutectic point.

Comparing the values of the specific resistances in table 4, it may be seen that small variations in the quantity of water present greatly affect the specific resistance at temperatures above −26.55 in the solid and liquid phases, while below the eutectic point, the specific resistance is not materially affected by the presence of small quantities of water. At−80°C the specific resistance of sample 3 is considerably smaller than that of samples 1 and 2 at the same temperature. This might be expected and it is probably due to the comparatively large amount of water in the solid form, stretching from one electrode to the other, thus increasing the conductivity of the mixture of ice and acetic acid, as the former has a greater conductivity than the latter. In tubes 1 and 2, the amount of water present is so small, that when frozen, it does not occupy sufficient volume to materially affect the sp. resistance.

Summary.

1. Three satisfactory methods have been investigated and used in the measurement of high electrolytic resistances.

2. The specific resistance of acetic acid in the solid and liquid phases, has been measured at temperatures ranging from −80°C to +27°C and sudden changes were found at the melting and eutectic points.

3.   The resistance in the solid phase above the eutectic point is found to vary in a peculiar manner, as the temperature changes.   This variation has been explained.

4.   The effect of small quantities of water on the resistance of the acid has been investigated and explained and it has been shown that the conductivity of the acid in the solid state above the eutectic point, is due almost entirely, to the presence of this water.

5.   The temperature coefficient in the liquid phase was found to be nearly constant and equal to 0.04.   In the solid phase it varies from 0.30 @ −43°C to 0.25 @ −70°C.

In conclusion I wish to thank Dr. Bronson for the inspiration and help which made this work possible.

DALHOUSIE UNIVERSITY, HALIFAX.
                    March 9th, 1914.

Notes on the Analysis of "Iron-stone" by Hubert Bradford Vickery,* Dalhousie University, Halifax.

Iron-stone is the name which is applied in popular usage to the rock which is at present finding considerable application as a building material in and about Halifax. For this purpose it has several advantages, and some disadvantages. On account of its structure and the presence of well-developed joint-planes, it is quarried into rectangular blocks with a fair degree of ease. The flat surfaces of the planes allow of its being built into a smooth wall, and the familiar iron-rust stains, where the rock has been exposed to the weather allow of artistic effects being produced by placing the colored blocks in symmetrical positions.

A decided disadvantage, however, lies in the difficulty which has been experienced in finding a cement which sticks closely enough to the stone to prevent seepage of water through the masonry, thus producing unsightly stains on the interior wall. This difficulty is being obviated, it is hoped completely, in the case of the new Science Building at Studley by building the wall double, using iron-stone outside and granite as a lining, for ordinary cement forms with granite a weather-proof wall.

From the geological standpoint, iron-stone is metamorphosed shale of great age, belonging as it does to the Pre-Cambrian period. In the course of geological time it has become greatly changed so that the orginal shale has now become a hard slate. Several influences have combined to produce this result. It has been very severely folded, in some places even crumpled, so that the originally flat-lying beds are now found in all attitudes, even approaching the per-

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* Contributions from the Science Laboratories of Dalhousie University (Chemistry).

pendicular, and the great folds may be traced all over the country wherever exposures occur.

Another important metamorphosing influence was the intrusion of great masses of granite in Devonian time. The effect of this was to harden the slate by baking it and to produce many minerals which give a characteristic spotted appearance as the contact with the granite is approached.

It is this hardened slate from near the contact which has received the name of iron-stone, and which is used for building purposes. Microscopic examinations of a series of sections of the slate taken from the proximity of the granite contact made last year by Prof. D. S. MacIntosh, gave evidence that the folding took place prior to the intrusion and also showed the development of a series of minerals, such as cordierite, in small ovoid patches found even at considerable distance from the contact, slender crystals of andalusite found nearer and also several other less prominent minerals, such as biotite, sericite and muscovite. The small amount of carbonaceous material in the orginal shale was changed to graphite and feldspar and quartz particles are found. Up to the present no fossils have been discovered, a circumstance which points alike to its great age and the severe metamorphosis that it has undergone.

As found in most localities, it is a hard dark grey rock, characterized by red stains of ferric oxide where it has been exposed to the action of the weather, of a rather homogeneous structure and stony appearance. Bands are found which contain so much silica and are so hard that they exhibit the phenomenon of conchoidal fracture. As the granite contact is approached the slate changes its appearance slightly and becomes what is known as spotted slate due to the development of minerals. Patches and small crystals of pyrites are common and under the influence of the weather, some of the minerals have dissolved out, giving a pitted surface.

The specimen used in the following analysis was procured from the grounds at Studley. It was quarried from across the North West Arm, near Halifax, in the old King's Quarry, a few hundred yards from the contact with the granite. It was slightly mineralised but care was taken to select a specimen which had not been weathered to a sufficient extent as to become stained. By the courtesy of the Technical College it was reduced to a very fine flour in their machines, and was then very carefully mixed. The actual specimen analyzed was obtained by selecting small portions from all parts of the mass, and these portions were again ground in an agate mortar until no grit was perceptible. A weighed-out portion of this was taken and thoroughly mixed with about eight parts of sodium carbonate, placed in a platinum crucible, and two more parts of sodium carbonate placed on top.

The crucible was heated gently at first and then more violently until a clear fusion took place, the crucible being meanwhile loosely covered. On cooling, the crucible and its cover were placed in a solution of 50^{cc} hydrochloric acid in 100^{cc} of water and allowed to thoroughly disintegrate. The residue of silica was filtered off and washed, and the filtrate evaporated to dryness and dehydrated on the water-bath for two hours, the residue moistened with concentrated hydrochloric acid, and dissolved in about 150^{cc} water, filtered and washed.

A second evaporation and dehydration was found necessary in only a few cases. The silica was carefully ignited to constant weight. It was then treated with a few drops of concentrated sulphuric acid and hydrofluoric acid and warmed to expel the silicon tetrafluoride and finally the sulphuric acid and the crucible again weighed. The difference of these two weighings gave the silica contents of the iron-stone which was found to be 58.05%. The residue in the crucible, which was chiefly iron and aluminum oxide, amounted to .0140 g. and as an even gram portion had been taken

this reads 1.40% which will be added to the determination of iron and aluminium oxides.

The filtrates from the silica were combined and the iron and aluminium contained determined in the following way:—

A few drops of bromine water were added and the solution boiled to oxidize any ferrous iron present, and a considerable volume of ammonium chloride added and the solution made slightly alkaline with ammonium hydroxide. The precipitated hydroxides were filtered off and washed carefully, dried in the oven and ignited to constant weight. This with the weight of the iron and alumina carried down by the silica gave a weight of .3225 g. or 32.25% of combined iron and aluminium oxides, assuming the iron to be all in the ferric condition.

The iron content was determined by preparing another sample as before, removing the silica and making the solution up to standard volume. Two accurate fractions were then taken and one titrated direct with standard permanganate solution to obtain the proportion of ferrous iron. This process is open to some objection as it is very difficult to ensure that no oxidation of the ferrous iron should take place during the processes of grinding the sample and of fusion, and the proportion calculated from it can only be approximixately correct. The other fraction was evaporated with sulphuric acid and the hydrochloric acid expelled. It was then reduced by means of a Jones reductor and titrated with standard permanganate. Thus the ratio of the ferrous iron to total iron was established and from it the proportions of the two oxides calculated, proving to be ferrous oxide 1.72%, ferric oxide 4.51%—total iron 6.23%.

The calcium and magnesium were determined by the Richards method. This method is based upon the fact that the amount of magnesium occluded by the calcium oxalate precipitate, depends upon the concentration of magnesium

molecules present. Hence the ionization of the magnesium is favoured in every way possible.

In detail the procedure consists in diluting the filtrate from the iron and aluminium to about 500^{cc} and adding ammonium choride in some quantity, and to precipitate the calcium a boiling solution of oxalic acid is added, which contains three or four equivalents of mineral acid. A few drops of methyl orange are added and the solution neutralized very slowly (at least half an hour for complete neutralization). Considerable excess of hot ammonium oxalate is added and the solution allowed to stand some hours and the calcium oxalate filtered off and washed chloride free with a one per cent. solution of ammonium oxalate. The precipitate on careful ignition yielded decimal 67% of calcium oxide.

The magnesium was determined by evaporating the filtrate until salts began to crystalize out and then diluting until these just dissolved. Then exactly one-third volume of strong ammonia was added and an excess of sodium hydrogen phosphate. The precipitate formed is magnesium ammonium phosphate and this on ignition yields magnesium pyrophosphate from which the magnesium oxide content was calculated, proving to be 1.18%.

Sulphur was determined by taking fresh samples of iron-stone and fusing with ten parts of a mixture of four parts sodium carbonate with one of potassium nitrate. The samples were very carefully mixed and fused by heating the crucible placed in a hole in an asbestos board to deflect any gases from the flame which might contain sulphur. When all action had apparently ceased the residue was cooled and repeatedly extracted with boiling water and finally with boiling dilute sodium carbonate solution. The solution thus obtained was made acid, evaporated and the silica dehydrated and the nitric acid expelled by moistening with hydrochloric acid, and again evaporating. The silica was then filtered off and

the filtrate diluted to 400^{cc} brought to boiling and hot barium chloride solution added very slowly in slight excess and the solution allowed to digest for some hours. From the precipitate of barium sulphate the sulphur content was calculated and found to be 1.67%.

The water contained in combination was estimated by igniting a fresh sample for some hours in a covered crucible to constant weight. This was found to give a proportion of volatile matter of 6.49%. As this, however, probably includes the sulphur a determination of the sulphur contained in the residue was made showing that over two-thirds of the total sulphur had been driven off. This weight subtracted from the total loss of weight on ignition gave the loss due to the volatilization of the water which was found to amount to 5.23%.

These results may be summarized as follows:—

<div align="center">" IRON-STONE."</div>

Silica			58.05
Combined Oxides: Alumina	26.02		
Ferrous Oxide	1.72		
Ferric Oxide	4.51	32.25	
Calcium Oxide		.67	
Magnesium Oxide		1.18	
Sulphur		1.67	
Water		5.23	
		——99.05	

A partial analysis of another sample of iron-stone was made, the specimen being taken from a rather silicious band very near the granite contact and with the minerals quite highly developed. The results were:—

Silica	64.48
Combined Oxides	26.06
Sulphur	.32
Magnesium Oxide	1.56
Volatile matter, including water and probably some sulphur	2.68

These figures show that considerable variation in composition may occur and the low proportion of volatile matter and sulphur and the high silica are significant of the effect of the granite intrusion upon the slate in its immediate vicinity.

Although the microscope reveals the presence of feldspar, it is in such small quantities that no effort was made to estimate the alkalis.

The following tables give the analyses of typical slates.

A black roofing slate from Vermont gave:*

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Silica.............................59.7
Combined Oxides: Alumina   17.0
                Ferrous Oxide      4.9
                Ferric Oxide..      .5...22.4
Magnesium Oxide.................  3.2
Calcium Oxide...................  1.3
Alkalis.........................  5.2
Water...........................  4.1
Other Oxides and Carbon.........  4.3
                              ——100.3
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A slate from Wales gave:

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Silica.............................60.5
Combined Oxides: Alumina   19.7
Ferrous Oxide.             7.8...27.5
Magnesium Oxide.................  2.2
Calcium Oxide...................  1.1
Akalis..........................  5.4
Water...........................  3.5
                              ——100.2
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INTEGRAL ATOMIC WEIGHTS, PART 1.—BY FRANK WILLIAM DODD, Assoc. Mem. I. C. E., Weymouth, England.

This constitutes a suggestion that the accepted series of atomic weights are fractional parts of a series of higher or Integral Atomic Weights which more correctly represent the properties and constitution of the atoms, except in the matter of weight.

The author was led to make a large number of calculations with a view to find traces of such a series of Integral Atomic Weights, and, at length, found that if the accepted atomic weights were scaled off as ordinates at convenient horizontal distances, and a curve drawn, as shown in Fig. 1, it was possible to draw certain horizontal lines AB, CD, EF, GH, JK, above the curve, in such positions that the specific gravities of the few elements beneath any given horizontal line were a very simple function of the distance between the horizontal line and the curve at that point. Not only so, but the distances of these horizontal lines from the base line were simple functions of of each other.

That is to say, referring again to Fig. 1, that the upper or dotted portions of the atomic weight ordinates, which we may call super-ordinates, are very simple functions of the specific gravity of the elements to which they refer, and that the heights of the lines AB, CD, EF, GH, and JK, above the base line, bear the simple proportions 128, 132, 136, 232, 224, all but one of which are multiples of 8 and the remaining one a multiple of 4.

The super-ordinate divided by 1.8 gives the specific gravity approximately.

The author was led to complete the series but found that in most other parts of the curve a line had to be drawn for

(216)

Fig. 1.
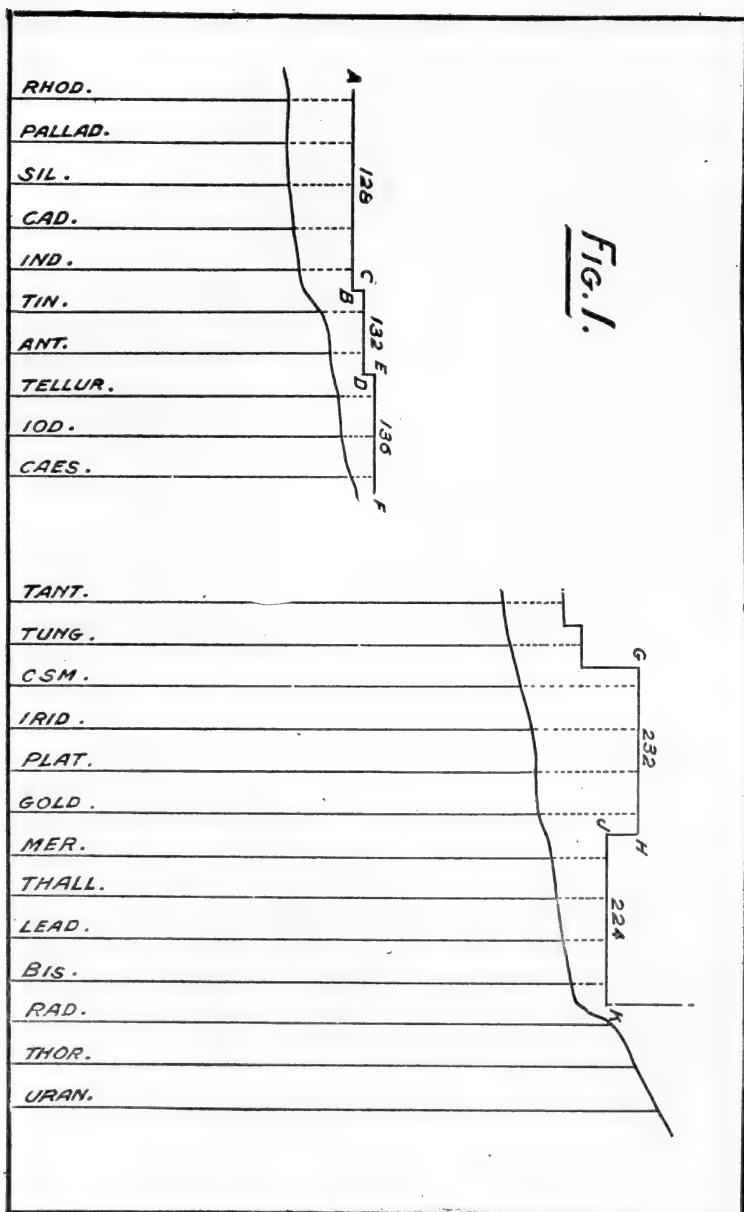
each single element. Nevertheless, the heights of these lines persisted in approximating to multiples of 4 or 8 with a few exceptions. Where it is a multiple of 3, that will crop up repeatedly in the same group of elements. Similarly when it is a multiple of 5. This happens, by the way, in the pentad group, which is decidedly interesting.

He afterwards found that the ratio $\dfrac{\text{super-ordinate}}{1.8}$ approximated more closely to the specific gravity if the heights of the horizontal lines above the base were measured with 1.008 (atomic weight H) as a unit instead of with 1 as a unit.

The number of units in the ordinates running from the base line right up to the horizontal lines may be called the "Atomic Multiples"; and the Atomic Multiples × 1.008 are what have been called above, the "Integral Atomic Weights."

A list is given in Fig. 2, of these Atomic Multiples, arranged after the manner of Mendeléeff's table.

It will be found that,

$$\text{Specific Gravity} = \frac{\text{Integral At. Wt.—actual At. Wt.}}{1.8}$$

with an average error of 0.55. A large number work out with great accuracy.

Manganese is not very amenable to the system, but it should be remarked that it stands very much alone in its group any way.

It is well to keep the two factors of the Integral Atomic Weight—namely the Atomic Multiple and the unit of 1.008 —separately in mind, as it may be found desirable to alter the the Atomic Mutltiple for any element, or the unit for all the elements in order to get more precise results later on.

Melting Points.

These Atomic Multiples have a very distinct relation to the melting point curve of the elements. As the list of the

Fig. 2.

Li. 8									
Be 12	Na.24								
B 15	Mo.27	Al 32							
C 16	Si.32		Cl.36						
	P.35	S.36		Fe 68 Co 72 Ni 72					
Ti. 54	V.60	Cr.64							
Ge 80	As 84	Se 84	Br.86						
K.40	Ca 42								
Cu.80	Zn 80	Ca 80							
Ru.88	Sr 88	Y.96		Nb.105	Mo.108				
Ag 128	Co 128	In 128	Sn 132	Sb 132	Te 136	I.136	Ru 116 Rho 128 Pd 128		
Cs.136	Ba 144	Ce 152							
				Ta.204	W.216			Os 232 Ir 232 Pt 232	
Au 232	Hg 224	Tl 224	Pb 224	Bi.224					
	Ra 248 ? 236		Tn 248		U.272				

elements progresses, the Atomic Multiples either remain constant or rise (with one exception).

While they remain constant, the melting point curve falls rapidly. Where they materially increase, the melting point rises abruptly. Small increases only just check the fall of the melting point curve or may just give a slight rise, thus forming the double periodicity humps. This is most readily seen by marking the Atomic Multiples on a melting point curve. It will be seen that in the one instance where the Atomic Multiple falls the melting point drops below zero.

Specific Heat.

The Integral Atomic Weight of an element multiplied by the specific heat of the element is a more constant quantity than the ordinary atomic weight of an element multiplied by its specific heat, the departure from a mean being reduced by about 30 per cent. In the lower parts of the scale the reduction of variation is much more than this.

Conclusions.

The author thinks there is strong evidence that these suggested Integral Atomic Weights are a real function of their respective elements, and if they be accepted the inferences are:—

(a)   That the heavier elements are built up from the lighter elements with probably hydrogen, helium, and possibly lithium largely as constituents, these sub-atoms being conjoined in some vibratory system which renders a part of their material unnecessary to the structure of the complex atom; for if the Atomic Multiple, or the Integral Atomic Weight be taken as proportional to the number of ultimate sub-atoms constituting any given atom, then the excess of these magnitudes over the accepted atomic weight may be

considered proportional to the loss of material in the formation of the atom.

(b) That the quantity of missing material is a very simple function of the closeness of the combination: that is to say of the density of the substance.

(c) That the specific heat of an element depends more upon the number of ultimate sub-atoms in its main atom, than upon the actual weight of the said main or complex atom.

(d) That with a given number of sub-atoms the melting point is a direct function of the quantity of missing material, so that melting point curve and specific gravity curve are similar so long as the number of sub-atoms (i. e., the Atomic Multiple) remains constant.

A curve showing the closeness of agreement between actual specific gravities and those worked out by the above method, is appended (**Fig. 3**).
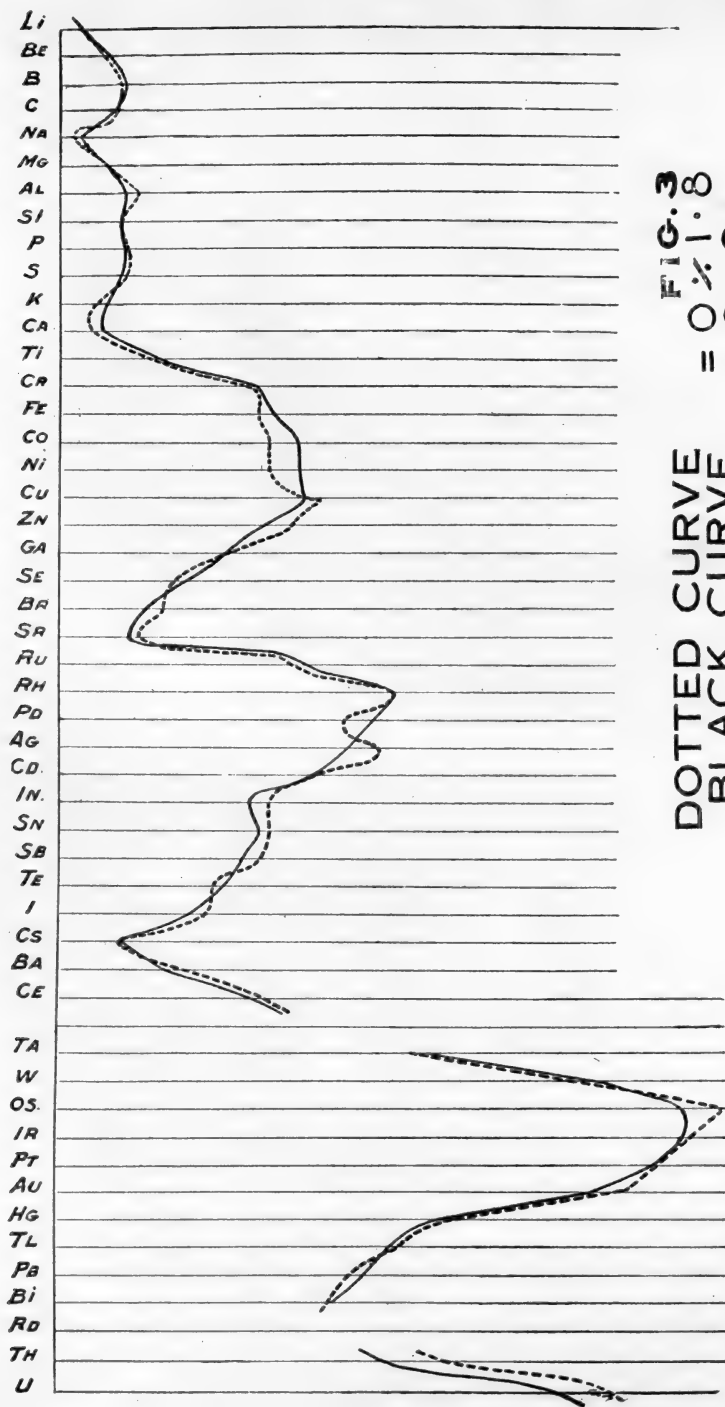
FIG. 3

DOTTED CURVE = O % 1·8
BLACK CURVE = SP. GR.

Integral Atomic Weights, Part 2. — By Frank William Dodd, Assoc. Mem. I. C. E., Weymouth, England.

Since reading the short paper on this subject in November, 1912, at a meeting of the Nova Scotian Institute of Science, the author has given further consideration to the subject, and has also received and considered numerous criticisms.

The most important of these criticisms and one which, being fairly obvious, was advanced from several quarters, was based on the fact that the specific gravity of an element is not a definite and inherent quantity, but is dependent upon temperature and other conditions, physical and mechanical, and may vary widely for the same element.

The author's first paper may be summarized in a sentence. It suggested that if the specific gravity of the elements of a group multiplied by a suitable factor be added to the atomic weights of those elements, a series of numbers is obtained which very strongly suggests a system of Integral Atomic Weights, and the building up of the heavier elements from the lighter.

The question arises,—which specific gravity, seeing that an element may have a great range of specific gravity?

In the present paper I have to suggest that each element has what may be termed a Natural Specific Gravity, any departure from which may be regarded as more or less accidental. This Natural Specific Gravity results from the combination of certain volumes in a definite manner, analagous to the mode of combination of gases; producing a resultant compound with a specific volume having a definite

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and simple relation to the specific volumes of the constituents.

To illustrate this suggestion the following table, Fig. 1, is arranged showing the actual specific gravities of the elements in Group I in comparison with what I suggest are the Natural Specific Gravities. Gold is omitted as it seems to belong to another group as far as this system is concerned. The agreement between the observed specific gravities and the Natural Specific Gravities based on the Atomic Multiples, affords a confirmation of the real connection of the Multiples with the actual physical properties of the elements.

With this new suggestion in view the author invites attention to the accompanying table, Fig. 2, relating to Group V, in which the Atomic Multiples are worked out from the Natural Specific Gravities. In other words—one assumption is made and one only—namely that the Natural Volumes of this Group are as shown on diagram Fig. 3. This shows only three Natural Volumes for the eight elements. It is thought that the diagram will show that the assumption is not a rash one.

The Atomic Multiples arrived at, show very close approximation to multiples of 5, so close that it is at least 1,000,000 to one against this being a mere chance result.

As I foresaw in reading my first paper, some of the Multiples have had to be slightly modified on further consideration, and as the subject develops.

F. N DODD on INTEGRAL ATOMIC WEIGHTS

FIG. 1

	ATOMIC MULTIPLE	NATURAL VOLUME	NATURAL SPECIFIC GRAVITY	NAT. SPEC. GR. REDUCED TO WATER BASIS	OBSERVED SPECIFIC GRAVITY FOR COMPARISON
Li. 7	8	$\frac{24}{2}$	$\frac{2}{3}$	·5883	·534
Na.23	24	24	1	·8825	·9735
K.39.1	40	40	1	·8825	·896
Cu.63.57	80	8	10	8·8250	8·925
Rb.85.95	88	44	2	1·7750	1·532
Ag.107.88	120	10	12	10·5900	10·530
Cs.132.81	136	68	2	1·7750	1·870

FIG. 2

F.W.DODD on INTEGRAL ATOMIC WEIGHTS.

GROUP V.

FULL LINE SHOWS OBSERVED AT. VOLS.
DOTTED LINE   "   AT. VOLS. BASED ON INTEGRAL ATOMIC WEIGHTS

F.W.DODD on INTEGRAL AT. WEIGHTS
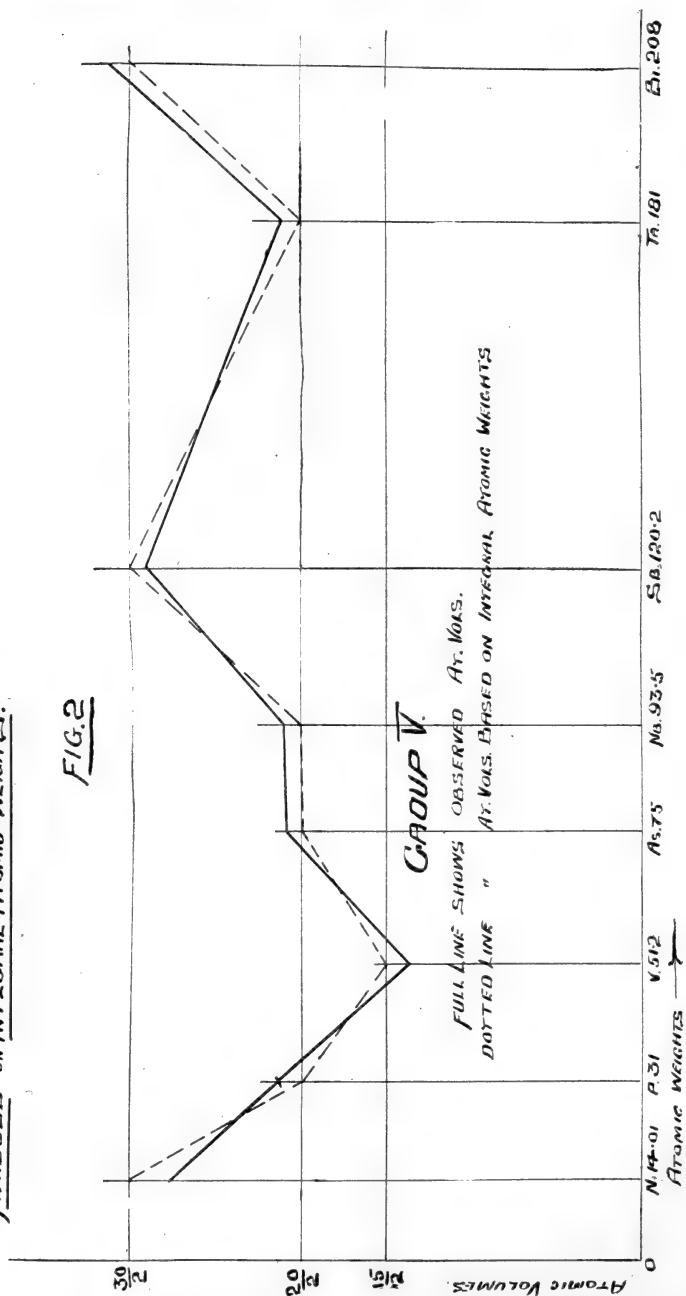
FIG. 3

ELEMENT	SUGGESTED ATOMIC MULTIPLE	NATURAL VOLUME	NATURAL SP.GRAVITY	ATOMIC WEIGHT PLUS NAT. SP.GR.×1·1325	ERRORS i.e. DEPARTURE FROM SUGGESTED MULS.	
N.14.01	15	$\frac{30}{2}$	1·0	15·1425	·1425	
P.31	35	$\frac{20}{2}$	3·5	34·96375	·03625	
V.51·2	60	$\frac{15}{2}$	8·0	60·26	·26	
As.75	85	$\frac{20}{2}$	8·5	84·62625	·37375	
Cb.93?	105	$\frac{20}{2}$	10·5	105·39125	·39125	
Se.120·2	130	$\frac{30}{2}$	8·66	130·01500	·01500	
Ta.181	205	$\frac{20}{2}$	20·5	204·1625	·8375	
Bi.208	225	$\frac{30}{2}$	15·0	224·9875	·0125	

MEAN ERROR IN A CHANCE COMBINATION WOULD BE 1·25

The Occurrence of European Birds in Nova Scotia.—
By Harry Piers, Curator of the Provincial Museum of Nova Scotia, Halifax, N. S.

At intervals there have been taken on the eastern shores of the Western Hemisphere, birds which belong more strictly to the Old World, and the purpose of the paper is to record a few recent occurrences of the kind in Nova Scotia, such as those of the European Widgeon, the European Teal, and the Lapwing, as well as to bring together some particulars of all such previous records as have come to my knowledge. To this is added some information about the Dunlin and Wheatear, which have been, apparently erroneously, stated to have been taken in this Province.

Of the nine species mentioned, all belong to the so-called "Water Birds." Two of these are members of the order *Anseres* (Ducks, etc.), one of the *Paludicolæ* (Rails, etc.), and the remaining six of the *Limicolæ* (Snipes, Sandpipers, etc.). Nearly all of them are known to occur in Greenland or Iceland, and their breeding range is within or approaches the Arctic Circle. We have no instance, that I know of, of a bird with an exclusively more southern breeding area, occurring in Nova Scotia.

The few dates available for the occurrences given, are as follows, arranged in order of months: 9 Jan., 14 Feb., 17 Mar., 23 and 27 May, 1 and 28 Sept., Oct., and 12 Dec. Although these data are far too scanty to form any definite conclusions, one is led to think that the occurrences may be mostly referable, as would be expected, to the vernal and autumnal migrations. The winter and very early spring dates, however, are difficult to account for, unless the birds

had remained here after the fall migration, whereas one would expect them to have passed southward to escape the severe season of the year. The March record could be accounted for by the bird being then in transit northward under the vernal migratory impulse.

Judging by the evidence, we are fully justified, I think, in assuming that these north-breeding water-birds have arrived on our coast by way of Iceland, Greenland, and Labrador or Newfoundland, which is the usual route taken by European birds coming to eastern America; and that none of them have ever flown directly across the whole Atlantic Ocean, as is a popular belief among many people who are not ornithologists. At the time of migration, they have, no doubt, been turned in our direction by heavy easterly gales or other stress of weather, rather than from any mere individual motive or impulse. The prevailing winds in the North Atlantic are from the southwest and west, with easterly eddies about the coast of Greenland, but a flight is apt to encounter an adverse easterly gale at any time. In passing to the mainland of North America, the greatest flight these storm-strayed individuals would have to undertake, would be only about the same as that they had been in the habit of successfully taking from the British Isles to Iceland.

Of course, some of our American birds are similarly met with casually in the Eastern Hemisphere, as in the case of our Baldpate or American Widgeon, and other birds, which are recorded in lists on the east side of the Atlantic.

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EUROPEAN WIDGEON. *Mareca penelope* (Linn.). A.O.U. No. 136.—A male of this species was shot at Melbourne, on Chebogue Harbour or River, about five miles southeast of Yarmouth, Yarmouth county, Nova Scotia, on 9th January, 1912, by James Allen. It was mounted by Benjamin Doane, taxidermist of Yarmouth, and in November, 1912, was

purchased from him and added to the collection of the
Provincial Museum at Halifax (accession no. 3829). The head
and neck are rufous-brown; crown creamy-white. Length,
as mounted, about 18.00 inches; wing, 9.85 inches; tarsus,
1.40 inches; bill, 1.32 inches. E. C. Allen, of Yarmouth,
who first informed me of the taking of the bird, said that
there were two other ducks like it in its company at the
time; but these, I think, may have been Baldpates (*Mareca
americana*) with which it is sometimes found.

This, I think, is the first fully-recorded instance
of this European bird's occurrence in Nova Scotia, for
although mentioned in Andrew Downs's "Catalogue of the
Birds of Nova Scotia" (*Trans. N. S. Inst. Nat. Sc.*, 1888,
vii, 147), with the mere statement "rare," no other particu-
ars are given, and it is not included in Dr. J. B. Gilpin's
" Semi-annual Migration of Sea Fowl in N. S." (*Trans. N. S.
I. N. S.*, v, 138). The word "rare," at any rate is not suf-
ficiently strong to correctly indicate it as a mere accidental
visitor. The locality "Nova Scotia" given in Coues's *Key
to N. A. Birds* is referable back (per *The Auk*, Jan., 1889,
p. 64) to Downs's statement. M. Chamberlain, in his edition
of *Nuttall's Ornithology*, vol. ii, 1891, p. 313, says that
"every year more or less examples are seen along our coast
from Nova Scotia to Virginia". Chapman in his *Handbook
of Birds of Eastern North America*, 1912, p. 194, says the
species "is of rare but regular occurrence in Eastern North
America," and has been taken in New York, Nova Scotia,
Newfoundland, and Greenland, south to Nebraska, Missouri,
Indiana, Ohio, North Carolina, and Florida, as well as in Alaska,
British Columbia, and California. All the Nova Scotia refer-
ences, I am convinced, can be referred to Downs's vague note.

The species is a native of the northern part of the Eastern
Hemisphere, and it breeds within the Arctic Circle in Iceland,
and very possibly may be found breeding in Greenland. Its
somewhat regular casual occurrence in parts of North America,

and its being found in Iceland, Greenland and Newfoundland, make it almost doubtless that it finds its way here, as other species do, under stress of weather, along that route, which would furnish resting places, and that it does not fly directly across the Atlantic from the east.

It has been mentioned that our own American Widgeon or Baldpate (*M. americana*) occurs casually in Europe. It breeds as far north as lat. 68°, which is about the same as that of Iceland.

EUROPEAN TEAL. *Nettion crecca* (Linn.). A. O. U. No 138.—The first known occurrence of this European species in Nova Scotia, was a specimen taken near Halifax, by Dr. J. B. Gilpin, on 1st September, 1854. It was mounted by the late Andrew Downs and shown at the Dublin International Exhibition of 1865, and was purchased there by Sir Arthur Guinness for his collection. (See Gilpin, "Sea Fowl of N. S.," *Trans. N. S. Inst. Nat. Sc.*, v, 141; Chamberlain, *Catalogue of Canadian Birds*, 1887; and Downs, "Catalogue of Birds of N. S.," *Trans. N. S. I. N. S.*, vii, 148).

Another specimen, an adult male, not hitherto recorded, was shot at Mineville, near Lawrencetown, Halifax county, N. S., on 14th February, 1913, by J. R. Shaw of Mineville; and was purchased by the Provincial Museum (accession no. 3980). The long scapulars are creamy-white internally, and black externally, producing two very conspicuous contiguous longitudinal bands, as is typical in this species. There seems to be also a very slight difference in the tint of the green of the speculum of this specimen as compared with that of the Green-winged Teal. Another duck which was shot in company with the one just mentioned, lacks these bands, and is evidently a male of the ordinary Green-winged Teal (*Nettion carolinensis*), which otherwise much resembles it. This specimen is also in the Museum collection (accession no. 3981.) The two above records are the only ones for this province known to me.

This species is a native of Europe, breeding as far north as Iceland, and a few specimens have been killed in Danish Greenland and one in Labrador, and it occurs casually on the North American Atlantic coast as far south as Washington, D. C.

CORN CRAKE. *Crex crex* (Linn.). A. O. U. No. 217.— The late James McKinlay, a local ornithologist of Pictou, N. S., in October, about the year 1873, while snipe shooting on a wet grassy spot about a mile in the rear of Pictou town, shot a specimen of this Old World species. It remained long unidentified in his collection, until it was examined by Frank M. Chapman, author of the *Birds of Eastern North America*, when he visited Pictou in July, 1898. It is the only record for this province. (*Vide* information furnished me by Mr. McKinlay, 21st July, 1898, and his note in *The Auk*, Jan., 1899 ; also Macoun's *Cat. of Can. Birds*, 1909, p. 154.) This bird is a native of Europe and northern Asia, and occurs casually in Greenland, Newfoundland, and as far south as New Jersey and the Bermudas. Sandford, Bishop and VanDyke (*Water-fowl Family*, 1903, 294) say it breeds regularly in Greenland, but I do not find this noted in other works.

DUNLIN. *Pelidna alpinia alpinia* (Linn.). A.O.U. No. 243. —This Old World representative of the American Red-breasted Sandpiper is taken occasionally in Greenland, and has been also recorded as accidental on the west side of Hudson Bay, on Long Island, N. Y. and at Washington, D. C. It breeds in Scotland and the islands to the north thereof, and occasionally in England and Iceland, etc. north to latitude 74°.

Gilpin, is his "Shore Birds of Nova Scotia" (*Trans. N. S. Inst. Nat. Sc.*, v, 1882, p. 384), says that he had never met with the Dunlin in Nova Scotia, and he does not mention it in his list on page 385. On page 386 he says, "I have no distinct recollection of . . . seeing Dunlin's Sandpiper," but

adds, "I think there is a Dunlin immature bird in the Halifax Museum." A specimen in the Provincial Museum, unaccompanied by exact locality or date of capture, which is evidently the one referred to by Gilpin, is apparently a Red-backed Sandpiper in winter, or some state of immature plumage, its measurements being as follows: wing, 4.66 inches; tarsus, 1.00 inch; bill, 1.40 inches; middle toe with claw, .95 inch; middle toe without claw, .85 inch. These measurements all exceed the maximum ones of the Dunlin as given in Chapman's *Handbook*.

Macoun, in his *Catalogue of Canadian Birds*, 1909, p. 177, gives it as a "rare migrant in Nova Scotia," appending to this statement the name of Harold F. Tufts. then of Wolfville, N. S. Mr. Tufts, in his "Notes on the Birds of King's County, Nova Scotia" (*Ottawa Naturalist*, xii, Dec. 1898, p. 175) gives the Red-breasted Sandpiper (*Tringa alpina pacifica*, Coues, =*Pelidna alpina sakhalina*, Vieill.) as "a rather uncommon autumn migrant; observed on the Long Island beach during September;" but he makes no reference in that list to the Dunlin (*P. alpina alpina*).

This note in Macoun's list I had at first thought must have been intended to refer to the Red-back Sandpiper, under which latter name he makes no specific reference to Tuft's record in the *Ottawa Natuarlist*, although he speaks of it generally as "a rare migrant along the Atlantic coast." Furthermore, although there is no doubt that the Dunlin might be expected to occur here accidently, yet the expression "rare migrant" could not adequately represent the mere casual nature of such a bird's occurrence in this Province; whereas it does express the relative rarity of the Red-backed Sandpiper.

Dr. Harold F. Tufts, now of Jamaica Plain, Mass., in answer to a recent enquiry of mine respecting the beforementioned record, writes: "In regard to the Dunlin, I remember well the bird I took for it, —it was shot at Long Island beach,

near Grand Pré, King's county, in the latter part of September, 1898 or 1899—I think 28th September, 1898. I fired into a small flock of sandpipers and brought down a White-rumped Sandpiper, two Red-backed Sandpipers, and one which differed from the latter and which to the best of my ability to identify with the aid of Chamberlain's revision of Nuttall's Ornithology, I decided was the Dunlin, which is said to occur not infrequently on this side of the Atlantic. However, the skin is not in existence now, and even my notes of the time have been lost or destroyed. I really think I was justified in calling the bird the Dunlin."

Dr. Tufts is a careful observer, but as very unfortunately his speciman is not available for reference, the record must stand as one which was probably correct, but which cannot now be absolutely verified.

CURLEW SANDPIPER. *Erolia ferruginea* (Brünn.). A.O.U. No. 244.—This is an Old World species which occurs casually in North and South America, being recorded from Alaska, Ontario, Nova Scotia, Maine, Massachusetts, New York, New Jersey, and the West Indies and Patagonia. It is said to breed on the Arctic coast of Siberia, and a set of eggs, supposed to be of this species, has been taken in Greenland, where the bird is said to occur. Little, however, is definitely known on these points. Gilpin ("Shore Birds of Nova Scotia," *Trans. N. S. Inst. Nat. Sc.*, v, 383), under the old name *Tringa subarquata*, says he had it noted as taken at Halifax, October, 1864, "but," he adds, "I am not certain."*

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*Gilpin's statement is slightly ambiguous on one point. The paragraph from which the above quotation is made, says, "The Cape Curlew I have noted Halifax, October. *Tringa subarquata*, Schinss sand piper, I note Halifax, October 1864, but I am not certain." Now Schinz's Sandpiper is one of the names of the White-rumped Sandpiper (*Pisobia fuscicollis*) and is not, I believe, applied to *E. ferruginea*. In his list on page 385, he gives "*Tringa subarquata*—Curlew Sandpiper," but not the White-rumped (Schinz's) Sandpiper (*P. fuscicollis*); and on the next page he says, "I have not mentioned in this list Schinze's Sandpiper, although my notes give him at Halifax, August, 1864. I have no distinct recollection of the bird, or of seeing Dunlin's an enlarged copy of it, in Nova Scotia."

It is included in his list in the latter part of that paper (p. 385). Downs speaks of it as very rare, and says he purchased one in the Halifax market ("Catalorue of Birds of N. S.", *Trans. N. S. I. N. S.*, vii, 154).

GREEN SANDPIPER. *Helodromas ochropus* (Linn.). A.O.U. No. 257.—The normal habitat of this species, which is the Old World representative of our Solitary Sandpiper, is the northern portions of the Eastern Hemisphere from the Arctic regions to the Cape of Good Hope, and from the British Isles to China. It breeds in Scandinavia, Russia and Siberia, south to Turkestan. D. G. Elliot, formerly president of the American Ornithologists Union, in his *North American Shore Birds*, 1895, p. 127, says "no record is obtainable that this bird has ever been seen alive in North America," and adds that it "is included in our fauna on the strength of a dealer in England having received a skin among a number of American birds from Halifax, Nova Scotia." This, he thinks is but negative evidence, and hardly of that satisfactory kind as to warrant the adoption of the species into the American fauna.

An individual of this species exists among a collection of birds from the Northwest Territories sent to the British Museum by the Hudson Bay Company; and Pennant says he also observed it among birds collected by Mr. Kuckan in North America (Richardson, quoted in Macoun's *Cat. of Canadian Birds*, 1909, p. 192). The A. O. U. *Check-list of N. A. Birds*, 1895, p. 94, notes it as "accidental in Nova Scotia," and Chapman's *Birds of Eastern North America*, 1912, p. 258, admits it as having been "twice recorded from America (Nova Scotia and Hudson Bay, Coues, *Auk*, xiv, 1897, 210);" and other writers mention this species in the same way. (See also *Bull. Nuttall Club*, iii, 1878, p. 49; and *The Auk*, xiv, 1897, p. 210.) If the Nova Scotian record is based, as no doubt it is, on the skin referred to by Elliot,

it must be slightly open to question in the minds of many ornithologists.

RUFF. *Machetes pugnax* (Linn.). A. O. U. No. 260.—
On 27th May, 1892, a young ruffless male of this species was shot at Cole Harbour, near Halifax, N. S., and was mounted by T. J. Egan. It was identified by the Smithsonian Institution, Washington, as above-mentioned, although some United States ornithologists considered it differed slightly in some points from the European bird, but these, I believe, were insufficient to make any real doubt as to the determination, and the record must be taken as correct.*
(See fuller account in Piers's "Notes on N. S. Zoology, No. 3," *Trans. N. S. Inst. Sc.*, viii, 1894, p. 402). It is the only occurrence of the species in Nova Scotia. It has occurred as a straggler on the Bay of Fundy coast of New Brunswick (*vide* M. Chamberlain), and one was killed on Toronto Island, Ontario, in the spring of 1882 (McIlwraith, *Birds of Ontario*, 1894, p. 154).

The Ruff is an Old World species, breeding from the Arctic coast south to Great Britain, Holland, Russia and Siberia; and winters throughout Africa, India, and Burma. It strays in spring and fall to the Western Hemisphere from Ontario and Greenland south to Indiana, North Carolina, Barbados, and northern South America, there being some fourteen records for the Atlantic coast. American records are given by T. S. Palmer, in *The Auk*, xxiii, 1906, p. 98.

WHIMBREL. *Numenius phæpus* (Linn.). A. O. U. No. 267.
—This Old World species has once been recorded as taken about 170 miles to the eastward of the Nova Scotian coast. On 23rd May, 1906, a female Whimbrel came aboard the steamship "Bostonian" when she was westward-bound and

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*The original specimen, I think, is now in the collection of William Brewster, of Cambridge, Mass., or of Mr. Boardman, and if not, must have been lost in the fire which destroyed T. J. Egan's collection in September, 1904.

almost sixty miles to the southward of Sable Island, N. S.,
in latitude about 43° north and longitude 60° west. It died
a short time before the steamer reached Boston. Mr. William
Brewster of Cambridge, Mass., got the skin in October,
1907, and it is now in his collection, there being no doubt
about the identification. (*Vide* letter of Mr. Brewster to
writer, and his notes in *The Auk*).

The species is a native of the Eastern Hemisphere, and
a fair number of specimens have been taken in Greenland,
where it is possible it may occasionally breed, although no
instance is known of its having done so. It is known to breed in
Iceland, Shetland Isles, Scandinavia and Russia. The Nova
Scotian record is the only one of its occurrence in North
America south of Greenland.

LAPWING. *Vanellus vanellus* (Linn.). A. O. U. No. 269.
—Two specimens of this bird have been taken here. The
first was one found dead on the shore at Ketch Harbour,
eleven miles south of Halifax, N. S., on 17th March, 1897,
and was mounted by T. J. Egan. It was very thin and had,
no doubt, died from starvation. This was the first record
of the species' occurrence in this province. (See Piers,
"Notes on N. S. Zoology: No. 4," *Trans. N. S. Inst. Sc.*,
ix, 1897, p. 258). The only previous record for eastern
North America south of Greenland was founded on a specimen
taken at Merrick, Long Island, U. S. A., in December, 1883
(*vide* Dutcher, *The Auk*, iii, 1886, p. 438).

A second Nova Scotian specimen was shot at Upper
Prospect, fifteen miles southwest of Halifax, on 12th Decem-
ber, 1905, by a man of that place. It is now in the Provincial
Museum of Nova Scotia, accession no. 2954, having been
purchased from T. J. Egan, who mounted it, in January, 1906.
(Vide *Report of Provincial Museum of N. S. for 1906*, p. 8).
It is interesting to note that a Lapwing was also taken at
St. John's, Newfoundland, on 27th November, 1905, which

must have come southward at the same time as the Nova
Scotian specimen. (Vide *The Auk*, xxiii, 221).

The Lapwing inhabits the northern parts of the Eastern
Hemisphere, breeding from Central Eruope and Asia, north
to the Arctic circle in Europe and latitude 55° north in
Siberia; and has twice been found in Greenland (in 1820 and
1847), and has also been reported doubtfully from Norton
Sound, Alaska, where Dall mentions the capture of what
he supposed to be this species, although he did not himself
see the specimen.

*European Bird Incorrectly Reported as Occurring in Nova
Scotia.*

GREENLAND WHEATEAR. *Saxicola œnanthe leucorhoa*
(Gmel.). A. O. U. No. 765a.—In conclusion some particulars
will be given regarding the Greenland Wheatear, a bird long
reported to have been taken in Nova Scotia, and is so mentioned
in most books. About the year 1854, or shortly before, J·
Cassin obtained a Wheatear skin which had been collected
and sent to him by a gentleman from Nova Scotia, and he,
not unnaturally, concluded that it had been taken in that
province, and so mentioned it as a Nova Scotian occurrence
in his *Illustrations of the Birds of California, etc.*, 1st series,
no. vii, 1854, p. 208. Nova Scotia until very recently was thus
given as a locality for its casual occurrence, for example in
the A. O. U. *Check List* of 1895, Chapman's *Birds of Eastern
North America*, 1895, etc. According, however, to Brewer
in his *History of North American Birds*, i, 1874, p. 60, Cassin's
specimen came in reality from Coal Harbour, Labrador,
and not from Nova Scotia at all, although the gentleman
who collected it was from that province. (See also Stejneger,
"Wheatears of North America," *Proc. U. S. Nat. Mus.*,
xxiii, 1901, pp. 473 and 479). The most recent works have
now dropped Nova Scotia from the localities where it has

occurred, and we can no longer, therefore, consider it as a bird found here, although it is quite likely to be taken as an accidental visitor at any time. The occurrence of the Wheatear in North America at all, was formerly thought to be only accidental or occasional, but the bird has since been ascertained to be a regular breeder in our northern regions, although nowheie appearing as a regular migrant on this continent.

In 1901, Stejneger (*loc. cit.*) separated the form which breeds in northeast boreal America, under the subspecific name *Saxicola œnanthe leucorhoa* (Gmel.), the Greenland Wheatear, A. O. U. No. 765a, recognizing the typical Wheatear, *S. œnanthe œnanthe* (Linn.), A. O. U. No. 765, as the form which occurs in the northwestern part of North America as well as in the Eastern Hemisphere. The Greenland Wheatear (the form which might be found accidentally in our own province) breeds regularly in the Arctic zone of North America, from Ellesmere Land and Boothia Peninsula, east to Greenland and Iceland, and south to northern Ungava, even possibly in part of Quebec. It migrates through the British Isles and France, and winters in western Africa. Chapman (*Birds of Eastern North America*, 1912, p. 499,) says it is "casual in migration to Keewatin, Ontario, New Brunswick [is "N. B." a typographical error for the old "N. S.," Nova Scotia, of his earlier edition?], Quebec, New York, Bermuda, Louisiana and Cuba." Should this sub-species ever occur here, it must now be considered merely as a casual occurrence of a true North American bird.

Curious Lightning Freak.—By Watson L. Bishop, Dartmouth, N. S.

On July 26th, 1903, a report came to me that our main twelve-inch water-pipe of cast iron, supplying the town of Dartmouth, Nova Scotia, with water, had burst and that a large quantity of water was flowing from the break. At · this place, about two miles from the town and one from the reservoir lakes, where the pressure would be about twenty-five pounds per square inch, the pipe-line was carried east and west, five feet deep, along an old road, the side of which was lined by a low rough stone wall. Several larch (hackmatack) trees were growing along this wall, some through its centre and others close along the sides. The pipe-line here is six feet from the wall.

On examination I found that one of these trees growing in the side of the wall had been shattered by lightning. The stump (or what remained of it) was three to four feet high, and was split in several pieces with the top ends well apart, showing that the great pressure was from the centre outward. The trunk of the tree, which was about ten inches in diameter, was shattered for a length of fifteen feet or more, and was scattered over a radius of about one hundred feet from the stump.

The remainder or top of the tree was left intact and fell vertically until the largest end was about six feet from the ground. In this position it was held by the branches of the other trees growing near by. The lower end was six inches in diameter and a stone weighing about twelve pounds was found firmly held in a cleft in this end, and appeared to have been driven by the lightning up through the centre of the

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tree until the force was spent, leaving the stone in the split as in a vice. The body of the trunk was so completely shattered into slivers that it took two men nearly half a day to collect the fragments from the unmowed hay-field on the other side of the wall.

The water-pipe was broken at a point nearest the shattered tree, nine feet distant. When the broken pipe was taken out it was found to be strongly magnetic. So strong is the magnetism even at the present time (December, 1912, nine years afterwards), that a handful of nails held to it will be drawn quite firmly to the edges of the break. A piece of steel rubbed a few times on this piece of pipe becomes so strongly magnetized as to pick up pieces of iron. The opposite ends of the break have opposite polarities as demonstrated by the magnetic compass and steel magnets.

The inference is that the electric current burst from the pipe-line to the tree, and on leaving the pipe broke it, and on entering the tree at its roots carried the stone up through the bursting trunk until, the force being spent, it remained in the split of the unshattered top.

Note on a Gastrolith found in a Moose.—By Professor D. Fraser Harris, M. D., C. M., D. Sc., F. R. S. E., Dalhousie University, Halifax.

On first October, 1905, a large bull moose (*Alces Amercanus*), eight or nine years old, and weighing 850 pounds was shot by Lieut. L. G. Matterson, R. A., at Ship Harbour, Long Lake, about ten miles south-east of Middle Musquodoboit, Halifax county, N. S. The guide, William H. Day, on opening the animal, found a hard oval concretion in its stomach. This was given to Mr. John W. Willis of Halifax, who possesses the mounted head of the animal. In May, 1912, Mr. Willis presented the calculus to the Provincial Museum (accession No. 3785). Mr. Piers asked me to examine the concretion and report on its chemical constitution. On cutting the calculus open carefully with a fret saw, I found it was a laminated concretion of oval section which now measured 1.90 inches in length (the end having broken off). The original length had doubtless been about 2.40 inches. The diameter of the section is 1.50 inches; and the thickness 1.15 inches. There are about seven concentric layers, every alternate one being somewhat more pronounced and more easily separated. In its centre was embedded a flat, smooth piece of slate not fully exposed in the section, but measuring 0.85 of an inch where it was exposed.

On submitting a fragment of the outer shell to chemical investigation, the substance proved to be calcium orthophosphate, with no obvious admixture of organic matter. According to the statement made by Mr. Day, communicated by Mr. Willis, the calculus was found in the stomach

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and not in intestine or bladder; it is, therefore, a gastrolith. Mr. Day states that he has known of a tooth being the centre of a similar concretion in the moose's stomach. Captain (now General) Campbell Hardy, R. A., in an unpublished paper entitled "Notes on the History of the Moose," read before this Institute on 7th May, 1867, exhibited and spoke of calculi formed in the stomach of that animal. The interest of this case is that the nucleus of crystallisation is a stone and not organic matter such as has so frequently been found in the "hair-balls" in horses and cows.

Notes on a Granite Contact Zone, Near Halifax, N. S. By Prof. D. S. McIntosh, M. Sc., Dalhousie College, Halifax, N. S.

A "Quebec and Maritime Provinces" excursion forms part of the programme of the Twelfth International Geological Congress which meets in Toronto in August of this year. According to the first planned arrangement, the party when at Halifax was to have visited a contact zone of the granite and slate in the vicinity of Chocolate Lake. Owing, however, to a change in the date of meeting of the Congress and some re-arrangement of itineraries, the party reaches Halifax on Sunday morning and departs early the following day. The proposed trip to this interesting locality was consequently abandoned. But while it was in contemplation some preparation was made for it. Dr. Young, who has charge of the excursion, together with Mr. Faribault and the writer of this paper, examined the rock of the district and procured specimens wherever there was any noticeable difference of texture or mineral constituents. From these specimens a series of microscopic sections were made. These thin sections the Geological Survey very kindly placed at the disposal of the writer for the preparation of this paper.

The granite batholith which forms the bed-rock of a large portion of the western part of the Province meets the metamorphosed sedimentary rock close to the southwestern shore of the North West Arm. The boundary line is irregular. Running in a general northwesterly direction from the Dingle, it passes south of Chocolate Lake, follows pretty closely the main road to Lily Pond, bends around between First and Second Chain Lakes, and thence has a westerly direction

until it crosses the Halifax and Southwestern railway and turns north. The granite is an intrusive of probably Devonian age. It evidently cooled and solidified under a great thickness of pre-existing rock, which has since been largely eroded. In the granite are found patches of darker, finer-grained material, which is probably the remains of blocks of the older rock partially assimilated. The effect of the high temperature of the intrusive magma produced a marked change in the overlying and surrounding rock masses. This change consisted largely in the development of new minerals out of some of the original constituents of the rock. As far as surface observations go, for upwards of a mile from the contact the influence of the heat was felt. A belt or zone of metamorphosed rock thus surrounds the igneous mass. Where the intruded rock varied in composition, the resultant metamorhpism differed somewhat. Of this contact zone the part more directly under discussion lies to the northwest of Chocolate Lake. (See map). In the northern and eastern
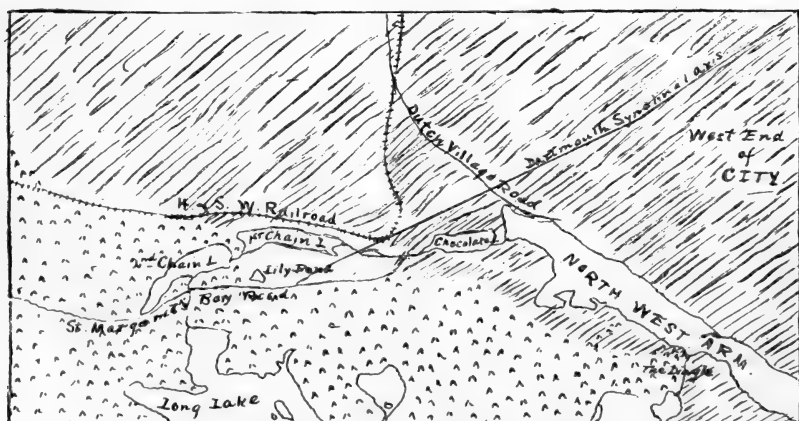
Map, showing Contact Zone — Granite ▦ · Slate ▨.
Sketched from C.G.S sheet N- '919. Scale: 1 mile = 1 inch.

section of this area, is the intruded rock, a black slate with a general easterly-westerly strike, and a south dip of 65° in the north which gradually decreases as the trough of the Dartmouth Synclinal is approached.

The original mineral composition of the slate beds varied somewhat. This is evident in the difference now seen in the rock; some are carbonaceous, others siliceous, while almost all the rock contains pyrite in varying proportions. This slate forms a part of the Upper Division of the Gold-Bearing series. The Halifax and South Western railroad passes through the area, and the numerous cuttings afforded means of easily obtaining material for examination. Samples of the slate were taken at intervals along the railroad from the point where it crosses the Dutch Village Road up to the contact with the igneous rock. Within this belt, metamorphism is excellently well shown. Even at the edge of the area, the furthest point from the nearest surface contact, metamorphic alteration is evidenced by the spotted appearance of the slate. Beyond this, doubtless, the rock is also altered, the zone being wider than the extent studied. Additional work could be done in tracing the result of the metamorphism from this point back into the unaltered slate. All through the contact zone the slate has a spotted appearance easily recognized, while as the granite is neared, long slender well-formed crystals are seen in the rock. The presence of these crystals from the cleavage faces of which the light is reflected, serves easily to distinguish it from the less altered spotted slate.

Microscopic examinations of the sections reveal a marked similarity between this granite contact and those more or less celebrated ones described from the Barr-Andlau of the Vosges Mountains, the Lake District of England, and elsewhere. The "base" of the slate, which is fine textured, is composed of sericite, minute grains of quartz and feldspars, graphite and other black carbonaceous particles. Probably very little, if any, of the original detrital material is present,

FIGURES × 62.

Fig. 1.—Cordierite slate (*crossed nicols*).
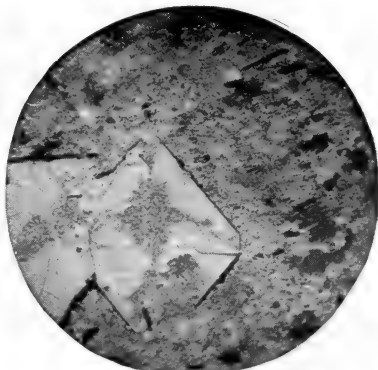
Fig. 2.—Andalusite—cordierite slate.
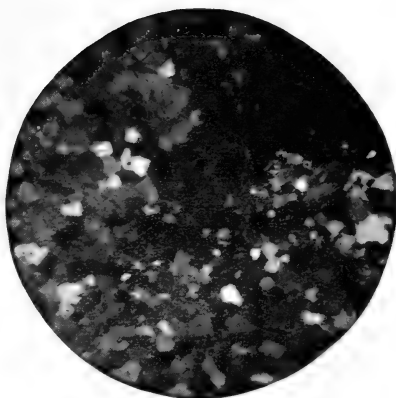
Fig. 3.—Siliceous slate (with pyrite) (*crossed nicols*).

Fig. 4.—Granite (*crossed nicols*).

the minerals enumerated above being largely recrystallisation products. Originally, the rock was probably a carbonaceous clay slate or shale. The grains and shreds all lie for the most part with their long axis in the same direction—that of the slaty cleavage. The re-crystallization is doubtless the result of pressure through a long period of time, and is itself the cause of the cleavage, normal to the pressure. This occured during the long time in which the folding was going on, which is evidenced in the present attitude of the rock and was prior to the intrusion of the granite. The proportion of the minerals of the "base" varies in the sections examined, in some sericite is more abundant, in others quartz, while in others there is more carbonaceous material. This difference is probably due to constituent varieties of the original beds. Pyrite is abundant in some laminae, in others almost absent.

Recrystallisation was probably completed before the contact metamorphism began. The first change brought about by the granitic intrusion was likely the production of a clear, brownish biotite in shreds and irregular crystals. Cleavage lines are rarely pronounced and inclusions are rare. Associated, and sometimes intergrown with it, is a colourless, slightly pleochroic mineral with rather high refraction, probably phlogopite. The biotite flakes are set at various angles to the cleavage planes and were, therefore, not affected by the pressure. It also occurs as inclusions in minerals to be described further on, which fixes its position in the time scale of metamorphism.

The spots so characteristic of the slate are found to be fibrous, ovoid and irregular patches of partially decomposed cordierite (Fig. 1). Unaltered portions occur at and about the centre of the patch, while the edges consist of a yellowish chloritic substance. The refractive index and double refraction are low. A faint bluish pleochroism is observable in one or two places. The crystal outline, which can be seen only between crossed nicols is mostly prismatic with occasionally

the characteristic pseudo-hexagonal form and twinning in segments and in included laminae. Irregular lenticular forms also occur. In the cordierite are inclusions of carbon, biotite, and quartz. These are remnants of the minerals which furnished the material for the formation of the cordierite and are consequently older than the containing mineral. The inclusions are arranged in lines parallel to the cleavage of the slate showing that the cordierite was formed after the cleavage and was not influenced by the pressure.

Within the area extending from the edge of the granite into the contact zone for a few hundred yards is the rock already referred to as being distinctive on account of the well developed crystals that appear in it. Here the influence of the hot granitic mass was most intense, and hence the metamorphism most pronounced. In the rock in this part of the belt are found the minerals already described as occurring in the other part, and in addition, fine andalusite crystals (Fig.2). These last occur as clear prism forms with prismatic cleavage. Where wedge shaped outlines are found, the extinction is in the direction of the wedge length, from edge to edge of the prism. The refraction is higher than that of the cordierite, the double refraction low. In an occasional spot on a crystal, the characteristic rose-red pleochroism is seen. Portions of some of the crystals are clouded with inclusions, while other parts are quite clear. All the other minerals of the rock form inclusions in the andalusite, so that it appears to have been the last to form. Its variety, chiastolite, occurs quite often in the slides. The carbonaceous inclusions are arranged in the cross section of the prism diagonally, the bulk of it occupying the corners of the prism, paralleling in a rough way the extinction of the crystal.

The only contact metamorphism noticed in the siliceous beds is the production of a few flakes of mica with perhaps a trace of scapolite and sillimanite (Fig. 3). A crystal of andalusite occurs in a slide from a small granite dyke that

extends into the slate. This doubtless resulted from the absorption of some of the slaty material, although no further evidence of such was found.

There is no evidence of any gases or vapours from the molten granite having been a factor in the alteration of the slate of the area studied.

Something like the following would be a sequence of events for this area. In Pre-Cambrian time, fine sediment containing a good deal of carbonaceous material was deposited in the water some distance off shore, on a slowly subsiding sea-bottom. This became consolidated into a carbonaceous shale. Pressure set in from the direction of the Atlantic seaboard, and continuing through long periods of time threw the great thickness of rock into high folds. The pressure converted the shale into a slate. Then in Devonian time came the intrusion of the granite, the heat from which changed the slate within the sphere of its influence into a cordierite-slate, and near the contact, where the alteration was greatest, into an andalusite-cordierite slate. During parts of the long periods that have elapsed since then, as well as in previous periods, erosion processes have been at work, resulting in the present day aspect of the area.

The Phenology of Nova Scotia, 1912.—By A. H. MacKay, Ll. D.

These phenological observations were made in the schools of the province of Nova Scotia as a part of the Nature Study work prescribed. The pupils report or bring in the flowering or other specimens to the teachers when they are first observed. The teachers record the first observation and observer, and vouch for the accurate naming of the species. The schedules from 200 of the best schools form the material of the following system of average dates (phenochrons) for the ten biological regions of the Province, and the phenochrons of the Province as a whole. The compilation of the 200 schedules was done by Walter M. Billman, M. A.

Regional phenochrons starred (*) are from supernumerary schedules which are not included in the general compilation, and thus do not affect the more general phenochrons. The nomenclature followed is that of Spotton or Gray.

THE PHENOLOGY OF NOVA SCOTIA, 1912.

[Compiled from over 200 local observation schedules.]

YEAR 1912

Day of the year corresponding to the last day of each month.

Jan.	31
Feb.	59
March	90
April	120
May	151
June	181
July	212
Aug.	243
Sept.	273
Oct.	304
Nov.	334
Dec.	365

For leap year add one to each except January.

WHEN FIRST SEEN — Observation Regions

No.	Species	1. Yarmouth and Digby	2. Shelburne, Queens and Lunenburg	3. Annapolis and Kings	4. Hants and South Colchester	5. Halifax and Guysboro	6. S. Copequid Slope (S. Cum. & Col.)	7. N. Cumb., Col., Picton and Antigonish	8. Richmond and Cape Breton	9./10. Bras d'Or Slope, Inv. and Victoria / Inverness Slope to Gulf	Average Dates
1	Alnus incana, Wild.	106	104	107	112	111	106	107	114	114	109.0
2	Populus tremuloides	125	111	120	120	124	122	117	122	127	120.9
3	Epigea repens, L.	96	101	102	108	107	110	111	121	118	107.8
4	Equisetum arvense	129	119	123	126	136	129	131	133	131	128.6
5	Sanguinaria Canadensis			134	124	126	123	127	132	154	133.0
6	Viola Blanda	120	121	123	126	127	126	130	136	132	126.0
7	Viola palmata, cucullata	123	126	126	126	130	129	131	142	134	128.9
8	Hepatica triloba, etc		124	140	130	132	126	129	135	134	132.8
9	Acer rubrum	138	122	125	163	129	162	161	168	134	130.8
10	Fragaria Virginiana.	127	124	121	132	164	130	133	139	168	127.3
11	" " fruit ripe	160	160	158	131	132	136	135	151	150	162.7
12	Taraxacum officinale.	128	124	144	134	134	136	134	138	135	130.9
13	Erythronium Americanum	143	136	134	134	125	136	130	138	135	124.4
14	Coptis trifolia	130	132	132	135	140	136	146	144	136	134.1
15	Claytonia Caroliniana			131	136	142	139	137	146	143	131.7
16	Nepeta Glechoma	142	135	134						148	139.1
17	Amelanchier Canadensis	142	137								140.1

WHEN BECOMING COMMON — Observation Regions

No.	Species	1. Yarmouth and Digby	2. Shelburne, Queens and Lunenburg	3. Annapolis and Kings	4. Hants and South Colchester	5. Halifax and Guysboro	6. S. Copequid Slope (S. Cum. & Col.)	7. N. Cumb., Col., Picton and Antigonish	8. Richmond and Cape Breton	9./10. Bras d'Or Slope, Inv. and Victoria / Inverness Slope to Gulf	Average Dates
1	Alnus incana, Wild.	118	110	115	119	120	114	113	120	122	116.8
2	Populus tremuloides	133	118	126	134	131	132	126	127	130	128.5
3	Epigea repens, L.	107	110	111	116	117	116	118	124	126	116.1
4	Equisetum arvense	138	125	129	132	146	130	136	138	135	134.3
5	Sanguinaria Canadensis			142	127	133		133		156	138.2
6	Viola Blanda	131	127	130	131	133	130	134	136	138	132.2
7	Viola palmata, cucullata	132	132	131	130	137	132	136	141	139	134.8
8	Hepatica triloba, etc		130	146	130	138			149		138.6
9	Acer rubrum	143	130	132	135	137	138	134	139	140	136.5
10	Fragaria Virginiana.	134	131	131	134	174	135	137	140	145	136.0
11	" " fruit ripe	173	168	168	172	137	171	172	176	176	172.4
12	Taraxacum officinale.	135	131	132	137		138	138	144	141	139.0
13	Erythronium Americanum		142	150	134	139	135	141	156	154	144.6
14	Coptis trifolia	140	136	141	140	130	142	139	143	143	140.1
15	Claytonia Caroliniana			137	133	145	137	134	145	149	137.0
16	Nepeta Glechoma	162	140	138	139	148	142	150	150	151	146.1
17	Amelanchier Canadensis	145	141	140	141		145	141	151	151	144.8

THE PHENOLOGY OF NOVA SCOTIA, 1912.—*Continued.*

Day of the year corresponding to the last day of each month.

Jan.	31	July	212
Feb.	59	Aug.	243
March	90	Sept.	273
April	120	Oct.	304
May	151	Nov.	334
June	181	Dec.	365

For leap year add one to each except January.

YEAR 1912

No.	Species
18	Amelanchier Canadensis fruit ripe
19	Prunus Pennsylvanica....fruit ripe
20	" " fruit ripe
21	Vaccinium Can. and Penn....
22	" " fruit ripe
23	Ranunculus acris
24	R. repens
25	Trillium erythrocarpum
26	Rhododendron Rhodora
27	Cornus Canadensis
28	" " fruit ripe
29	Trientalis Americana
30	Clintonia borealis
31	Calla palustris
32	Cypripedium acaule
33	Sisyrinchium angustifol.
34	Linnaea borealis
35	Kalmia glauca
36	Kalmia angustifolia
37	Crataegus oxyacantha
38	Crataegus coccinea, etc.
39	Iris versicolor
40	Chrysanthemum Leucanth.
41	Nuphar advena
42	Rubus strigosus

WHEN FIRST SEEN — Observation Regions

Average Dates (When First Seen):

No.	Avg. Dates
18	200.7
19	143.7
20	204.6
21	142.9
22	194.4
23	150.4
24	155.2
25	144.4
26	146.0
27	149.6
28	202.5
29	148.1
30	152.2
31	157.7
32	156.8
33	158.1
34	165.4
35	154.0
36	160.6
37	157.9
38	159.9
39	167.3
40	160.6
41	163.4
42	157.3

WHEN BECOMING COMMON — Observation Regions

Average Dates (When Becoming Common):

No.	Avg. Dates
18	227.5
19	148.8
20	213.0
21	150.0
22	211.2
23	157.8
24	161.1
25	148.8
26	151.7
27	155.8
28	222.0*
29	153.6
30	157.6
31	163.5
32	161.5
33	164.3
34	170.9
35	157.7
36	164.4
37	164.2
38	163.0
39	170.0
40	157.7
41	168.9
42	164.9

Observation region headings:
1. Yarmouth and Digby
2. Shelburne, Queens and Lunenburg
3. Annapolis and Kings
4. Hants and South Colchester
5. Halifax and Guysboro
6. S. Cobequid Slope (S. Cum. & Col.)
7. N. Cumb., Col., Pictou and Antigonish
8. Richmond and Cape Breton
9. Bras d'Or Slope, Inv. and Victoria
10. Inverness Slope to Gulf

No.		
43	Rubus strigosus fruit ripe	202.7
44	Rhinanthus Crista-galli	169.6
45	Rubus villosus	164.8
46	" " fruit ripe	223.9
47	Sarracenia purpurea	168.3
48	Brunella vulgaris	166.9
49	Rosa lucida	173.7
50	Leontodon autumnale	167.5
51	Linaria vulgaris	137.1
52	Trees appear green	112.0
53	Ribes rubrum (cultivated)	189.7
54	R. nigrum (cultivated)	144.4
55	" " (fruit ripe)	203.0
56	Prunus Cerasus fruit ripe	150.3
57		214.2
58		146.0
59	Prunus domestica	214.6
60	Pyrus Malus	146.4
61	Syringa vulgaris	148.8
62	Trifolium repens	155.7
63	Trifolium pratense	158.3
64	Phleum pratense	156.8
65	Solanum tuberosum	161.4
66	Ploughing (first of season)	180.2
67	Sowing	119.4
68	Potato-planting	129.3
69	Sheep-shearing	128.0
70	Hay-cutting	195.5
71	Grain-cutting	237.0
72	Potato-digging	262.7
73a	Opening of rivers	83.2
73b	Opening of lakes	105.3
74a	Last snow to whiten ground	109.3
74b	" " fly in air	119.4
75a	Last spring frost—hard	130.1
75b	" " —hoar	150.1
76a	Water in streams—high	96.5
76b	" " —low	207.5
77a	First autumn frost—hoar	260.3
77b	" " —hard	277.6
78a	First snow to fly in air	287.2
78b	" " whiten ground	304.8
79a	Closing of lakes	333.1
79b	" " rivers	352.2
81a	Wild ducks migrating, North	89.5
81b	" " South	310.6
82a	Wild geese " North	87.8
82b	" " South	301.4

THE PHENOLOGY OF NOVA SCOTIA, 1912.—*Continued.*

Year 1912. Day of the year corresponding to the last day of each month.

Month	Day	Month	Day
Jan.	31	July	212
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March	90	Sept.	272
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May	151	Nov.	334
June	181	Dec.	365

For leap year add one to each except January.

When First Seen — Observation Regions

Region columns:
1. Yarmouth and Digby
2. Shelburne, Queens and Lunenburg
3. Annapolis and Kings
4. Hants and South Colchester
5. Halifax and Guysboro
6. S. Cobequid Slope (S. Cumb. & Col.)
7. N. Cumb, Col, Picton and Antigonish
8. Richmond and Cape Breton
9. Bras d'Or Slope, Inv and Victoria
10. Inverness Slope to Gulf

No.	Species	Avg. Dates	1	2	3	4	5	6	7	8	9	10
83	Melospiza fasciata, North	97.2	96	94	93	99	93	101	99	97		103
84	Turdus migratorius "	88.3	83	85	84	89	85	84	91	96		98
85	Junco hiemalis "	96.5	90	89	109	92	85	95	93	91		125
86	Actitis macularia "	130.5	123	148	132	134	112	131	129	135		
87	Sturnella magna "	138.6	133	138	138	151	126	138	150			
88	Ceryle Alcyon "	123.2	125	122	128	120	122	127	121	120		
89	Dendrœca coronata "	129.5	129	128	136	130	131	129	131	128		
90	D. æstiva "	138.2	139	140	138	150	144	139	133			
91	Zonotrichia alba "	124.7	113	136	138	106	130	110	114			
92	Trochilus colubris "	145.4	142	143	138	143	133	157	147			
93	Tyrannus Carolinensis, North	135.7	135	143	137	139	133	153	119			
94	Dolychonyx oryzivorus	131.7	136	146	141	126	133	149	107			
95	Spinis tristis	141.9	136	150	148	157	154	153				
96	Setophaga ruticilla "	140.7	142	104	148	130	162	144				
97	Ampelis cedrorum "	148.2	145	130	121	163	121					
98	Chordeiles Virginianus "	129.8	132	113	136	121	130	149	125			
99	First piping of frogs.	107.3	126	98	132	101	111	112	104	115		125
100	First appearance, snakes.	115.3	112	103	112	110	112	121	122	121		125

When Becoming Common — Observation Regions (Average Dates; regions 1–10): no data recorded.

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1912.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION REGIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9 & 10. Victoria and Inverness.	Total reports of Thunderstorms for Year 1912.
	50								50
		52							52
		53							53
		64							64
		65							65
					66				66
				67					67
68									68
69^{3}		69^{4}	69^{2}	69					69^{10}
70^{3}		70^{2}	70^{2}		70				70^{8}
	72								72
				74					74
		75							75
	76^{2}	76							76^{3}
	77								77
78	78^{12}	78	78				78		78^{16}
	79^{33}	79^{3}	79	79^{2}		79^{3}			79^{42}
80	80	80^{4}		80^{7}		80^{4}			80^{17}
				81					81
	82			82					82^{2}
	85^{3}								85^{3}
							88		88
	97								97
				98			98		98^{2}
							99		99
					100				100
					101	101			101^{2}
						102			102
					103				103
		106		106^{2}		106	106		106^{5}
	107	107^{6}	107	107	107^{4}	107^{14}	107^{12}	107	107^{40}
		108^{2}		108^{2}		108^{4}	108^{10}	108^{3}	108^{21}
109^{2}					109				109^{3}
	110^{2}					110			110^{3}
	113^{2}			113					113^{3}
	114	114	114						114^{3}
	115^{31}								115^{31}
116	116^{5}	116^{2}	116	116					116^{10}
	117^{14}					117	117		117^{16}

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1912.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION REGIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9 & 10. Victoria and Inverness.	Total reports of Thunderstorms for Year 1912.
118	118[12]	.....	118	118[4]	.....	118	.....	.....	118[19]
.....	119[3]	119[2]	.....	119[2]	.....	119[3]	.....	.....	119[10]
.....	.....	.....	.....	.....	.....	.....	123	.....	123
.....	.....	.....	.....	124	.....	.....	.....	.....	124
.....	125	.....	.....	.....	.....	.....	.....	.....	125
.....	126	.....	.....	.....	.....	126	.....	.....	126[2]
.....	.....	.....	.....	127	.....	.....	.....	.....	127
.....	.....	.....	.....	.....	.....	128	.....	.....	128
.....	129[2]	.....	.....	.....	.....	.....	.....	.....	129[2]
.....	130[4]	.....	.....	130[2]	.....	130[2]	130	.....	130[19]
131[2]	131[2]	131[3]	131	131[8]	131	131[5]	131[3]	131[5]	131[30]
132	.....	.....	132	132[2]	.....	132	132	.....	132[6]
.....	.....	133	.....	.....	.....	133	.....	.....	133[2]
.....	134	.....	.....	.....	.....	.....	.....	.....	134
.....	135	135	.....	.....	.....	.....	.....	.....	135[2]
.....	.....	.....	.....	.....	.....	136	.....	.....	136
.....	.....	.....	137	.....	.....	137	137	.....	137[2]
.....	.....	.....	.....	.....	.....	138[2]	.....	.....	138[2]
.....	.....	.....	.....	.....	.....	139[2]	139	.....	139[3]
.....	140[7]	.....	140[3]	.....	140	140[11]	.....	140[2]	140[24]
141	.....	.....	.....	.....	.....	.....	141	.....	141[2]
.....	.....	.....	142	.....	.....	.....	.....	142	142[2]
.....	.....	.....	.....	143	.....	.....	143	.....	143[2]
144[3]	144[24]	144[3]	144[4]	144[4]	144[2]	144[11]	144[2]	144	144[54]
145[4]	145[8]	145[15]	145[7]	145[8]	145[10]	145[16]	145[15]	145[2]	145[84]
.....	146[2]	146[6]	146[4]	146[4]	.....	.....	146	.....	146[17]
.....	.....	147	.....	.....	.....	.....	.....	.....	147
.....	148[2]	148	.....	.....	.....	.....	.....	.....	148[2]
.....	.....	149	.....	.....	.....	.....	.....	.....	149
.....	.....	.....	.....	.....	.....	150	.....	.....	150
151	.....	.....	.....	151	.....	151	.....	.....	151[9]
.....	.....	153	.....	.....	.....	153	153[2]	.....	153[4]
.....	154	.....	154	154[2]	154	154	154	.....	154[7]
.....	.....	155[3]	155[10]	155[5]	155[10]	155[14]	155[5]	155[5]	155[52]
.....	.....	.....	156	.....	.....	156[2]	156[2]	.....	156[5]
.....	157	.....	.....	157	157	.....	.....	.....	157[7]
.....	.....	158	.....	.....	.....	.....	158	.....	158[9]
.....	.....	.....	.....	.....	.....	159[2]	.....	.....	159[2]
.....	160[4]	.....	160	160	.....	160[2]	160	.....	160[9]
.....	161[2]	161[3]	161	161	161	161[10]	161	161	161[20]

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, N. S., 1912.—*Continued.*

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION REGIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9 & 10. Victoria and Inverness.	Total reports of Thunderstorms for Year 1912.
			162			162^2			162^1
			163			163	163		163^1
				168^3		168	168^3		168^7
			169	169^5		169	169^6	169	169^{14}
							170^2	170	170^1
		172^2				172			172^2
173		173^6	173^6	173^2		173^5	173	173^3	173^{24}
174						174			174^1
							175	175	175^1
176			176^2						176^1
			177			177	177		177^1
		178		178			178		178^1
			179	179					179^1
182									182
						187^2			187^2
						190			190
						191			191
						192			192
						193			193
								200	200
						204			204
						205			205
				206					206
	209								209
						217			217
						219			219
						220			220
					223				223
						226			226
						228			228
						230			230
						236			236
						240^2			240^2
	245^4	245							245^5
	246		246		246	246^3			246^6
						252			252
						254	254		254^1
	255	255^3					255^3		255^7
		256^2	256^2		256^2	256^4	256^2		256^{12}
						257			257

THUNDERSTORMS—PHENOLOGICAL OBSERVAEIONS, N.S., 1912.—*Continued.*

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION REGIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9 & 10. Victoria and Inverness.	Total reports of Thunderstorms for Year 1912.
						258			258
							261		261
				262			262		262'
							263		263
						264	264²		264'
	265								265
	267								267
	268²								268'
	269³								269'
						272			272
	274²						274		274'
						279			279
						281			281
						282			282
					289				289
					290				290

TRANSACTIONS

ON THE EXISTENCE OF A REDUCING ENDO-ENZYME IN ANIMAL
TISSUES.—BY D. FRASER HARRIS, M. B., C. M., M. D.,
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(Read 10 November 1913)

I. HISTORICAL.

It has for many years been recognized that both living
and "surviving" animal tissues possess deoxidizing or re-
ducing powers.

Hoppe-Seyler[1] in 1883 was the first to draw attention
to the presence of powerful reducing processes in living
tissues. He suggested that, through reduction, molecular
oxygen was rendered active by conversion into nascent
oxygen and thus enabled to oxidize certain constituents of
tissues after the manner in which hydrogen-saturated pal-
ladium-foil can oxidize indigo.

Paul Ehrlich[2] two years later published his researches
on the reducing powers of tissues during life and at the
moment of death.

He classified tissues as regards their oxygen-avidity as follow:—

1.   Those in which indo-phenol blue remains unchanged: these he regarded as saturated with oxygen.   Examples; heart, renal cortex and the grey matter of the central nervous system.

2.   Those which reduce indo-phenol blue to indo-phenol white, but not alizarine blue to alizarine white; Examples: striated and non-striated muscle, gland parenchyma.

3.   Those which reduce alizarine blue to alizarine white, that is those with the greatest oxygen-avidity.   Examples; lung, liver, fat-cells and the gastric mucosa.

Ehrlich injected the pigments subcutaneously *intra vitam*; he noticed that a certain degree of heat arrested the reducing-power, but he did not suggest that tissue-reduction was due to an enzyme.

Between 1888 and 1909 J. de Rey-Pailhade[3] wrote on a substance he called philothion which he regarded as one of the mercaptans and indistinguishable from cystëine.   To this substance he attributed great importance in the fixation of oxygen by tissues.

Spitzer [4] in 1894 noticed that after the death of the animal, while the reducing powers of the tissues increased, the oxidizing capacity rapidly disappeared.   He also noticed that the temperature of 100° C might not always destroy the reducing power, whereas it always destroyed the oxidizing.

In 1895 Sir Victor Horsley and A. Butler Harris[5] made a report to the Scientific Grants Committee of the British Medical Association on the appearance of tissues of animals injected subcutaneously *intra vitam* with methylene blue. In the milk and in the urine a leuco form was found.   On faradization of the living cortex cerebri these workers demonstrated a state of reduction around the stimulated spot at a time when the blue coloration elsewhere was at its height.   The

decoloration was not due to ionized hydrogen at the kathode, for when the cortical excitability had disappeared, the reduction of the pigment at a stimulated spot could no longer be obtained.

These workers therefore recognized the simultaneous activity of two processes oxidation and reduction, the precise colour at any moment being the result of the relative predominance of the one process over the other. Frequently they found that oxidation prevailed over reduction.

In 1896 I[5]*found that living tissues of cat and rabbit, —kidney, liver, heart, glands—reduced the blue potassio-ferric ferrocyanide in the Prussian blue and gelatine injection mixture to the green or white leuco state of the dipotassio-ferrous ferrocyanide which on exposure to air slowly, or by treatment with hydrogen dioxide rapidly, became blue again.

The pigment was reduced only in the washed out smaller vessels and capillaries; in presence of blood not washed out of the larger vessels, the Prussian blue remained unreduced. The colour of the blood was therefore a purple.

In 1899 the term "reductase" as indicating a tissue-ferment, capable of effecting reduction processes seems to have been first used by Abelous and Gerard.[7]

Pozzi-Escot[8] in 1902 published the results of work on the reducing action of vegetable and animal tissues on solutions of indigo, litmus and Prussian blue out of contact with air. He confirmed Rey-Pailhade in finding that the tissues could form hydrogen sulphide from sulphur and could reduce potassium iodide when out of contact with air.

He held that a reductase might be suspected when a living tissue decomposes $H_2 O_2$, but does not affect a mixture of guaiacum and $H_2 O_2$.

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*At this date I had seen only Ehrlich's paper on oxygen avidity.

C. A. HERTER([9])in 1904 and 1905 published two papers on the reducing powers of living tissues. He injected methylene blue *intra vitam*. He stated that "the liver usually retains a high grade of reducing activity for several hours after death." He found lung, suprarenal capsule and grey matter of central nervous system all reduced the blue to the leuco state. An animal which was chilled by wet cloths or ice "exhibited the powers of reduction much diminished by cold". Herter showed that, conversely, the reducing power of the tissues of an animal injected with the micro-organisms of a specific fever was increased.

Underhill and Closson ([10]) in 1905 confirmed Herter's views and came to the conclusion that their experiments demonstrated the simultaneous action of both oxidative and reducing processes in the animal organism.

In 1906 Professor J. C. Irvine and I([11])showed that the *intra vitam* reduction of Prussian blue was not a deoxidation, but the removal of an ionic charge.

By perfusing the surviving kidney of a sheep with the Prussian blue mixture, I obtained from the ureter an absolutely colourless artificial urine which was blued immediately on treatment with $H_2 O_2$.

Authors with increasing frequency are recognizing the existence of reductase.

Oppenheimer ([12]), for instance in his large work on "Ferments" does so: most of the authors of text-books mention the reducing power of tissues even when they do not recognize "reductase".

Some, however, frankly postulate a reducing ferment; thus, G. P. Mudge([13])writes, "If an albino does carry a chromogenous body which only needs the influence of an oxidizing or reducing ferment to cause it to produce pigment", etc.

II. MATERIALS USED IN JUDGING OF REDUCTION BY
TISSUES.

These may be classified as:—

1.(a)Those containing,and (b)those not containing oxygen.

II.(c)Those which are and (d)those which are not pigments.

A. *Pigments*: 1. Containing oxygen: haemoglobin;
methaemoglobin; sodium-indigo-disulphonate.

2. Not containing oxygen: methylene blue; Prussian
blue.

B. *Non-pigments*: 1. Those with oxygen, e. g., sodium
nitrate.

2. Those without oxygen, e. g., ferric chloride.

III. METHODS OF STUDYING THE REDUCING POWERS
OF TISSUES.

All the following methods of bringing the pigments and
other substances into contact with the tissues or tissue-juices,
or other preparations of tissues have been tried: (a) immer-
sing pieces of surviving organs in the test substances; (b)
mixing the liquids with aqueous, saline or dilute glycerol
so-called "solutions" of reductase; (d) injecting surviving
organs with the Prussian blue and gelatine mixture; (e)
perfusing this injection mass or, for instance, ferric chloride,
through the vascular system of a surviving organ; (f) perfusing
the blood-vessels, and obtaining in the case of the kidney,
artificial urine, in the case of the liver, artificial bile.

As might be expected, the method merely of immersing
pieces of tissue was by far the least satisfactory. No good
results comparable with those got by Dr. Vernon ([14]) in the
case of oxidase were obtained, but in this respect reductase
resembles glycogenase, an undoubted endo-enzyme.

The routine method followed was to use the press-juice
from a Klein's press. This was kept sterile under toluene.
Its reducing power gradually declined in energy, until at the
end of three months it had vanished.

Various extracts of organs were made—aqueous, saline and glycerol—but as their reducing power was considerably weaker than that of press-juice, these were not extensively used in examining the properties of reductase.

Injection of the Prussian blue and gelatine mixture into the blood-vessels of organs was not used on many occasions. It was, however, originally by this method that my attention was drawn to tissue reduction, as I suspected that the "fading" of the mixture in the capillaries of the parenchyma of liver and kidney was chemically of the nature of a reduction.   This does not constitute a convenient method owing to the liability of the gelatine to "set" if the proper temperature is not maintained.

The revival of the blue colour in an injected and almost colorless kidney or liver cut open and exposed to the air or to the action of H_2O_2, is striking when seen for the first time. The vessels on the cut surface begin to show up like letters written in "sympathetic" ink.

It was by this method that I obtained an artificial, gelatinous, leuco urine from the sheep's ureter: it became blue on treatment with H_2O_2.

The method of injecting ferric chloride through the portal system and examining both the hepatic emergent fluid and the contents of the gall-bladder for ferrous chloride, in both of which it was found, proved a satisfactory method.

IV.   PREPARATION OF THE JUICE.

The following may be taken as typical of the technique.   A liver removed from the animal (rabbit, cat, dog, pig) before the heat has left it, is perfused through the portal vein with tap water at 40° C or with 0.75% NaCl until the water from the hepatic vein is colorless.   The organ is then rapidly cut into largish pieces from which a good deal of water is allowed to drain away.   The pieces are then cut up into much smaller bits and forced into the juice-press in which they are crushed

under considerable pressure. A fawn coloured, viscid liquid drips out and is received under toluene. This juice is subsequently ground up with powered glass and filtered through two layers of cheese cloth to free it from connective-tissue and the debris of blood-vessels, etc. Some preventative of putrefaction must be used although any such substance reduces the energy of tissue-respiration.

V. Description of a Typical Observation.

Three cubic centimeters of *absolutely fresh* press-juice prepared as just described, were shaken in a test-tube with 10 c.c. of 0.05% solution of soluble Prussian blue at room temperature (about 17° C). The blue colour began to disappear immediately, and in less than a minute after passing through light blue, light green and greenish grey, the mixture became light grey in colour. No trace of pigment remained.

When the same volume of *boiled juice* was used, no decrease in the intensity of the blue colour of the solution was observed at the end of several hours. The reducing activity of the juice was found to diminish somewhat rapidly with time. With a mixture containing 3 c.c. of the press-juice 24 hours old, and 10 c.c. of 0.05% Prussian blue solution, it was found that ten minutes elapsed before its colour became green grey, and two hours before it became completely colorless, (grey).

VI. Examination of Possible Fallacies.

Since the change from the coloured to the leuco condition is the sign of reduction having taken place, one must guard against confusing the fading of pigments through reduction with fading from causes other than bio-chemical reduction.

(a) The earliest criticism offered was that the fading of the Prussian blue was due to the presence of "alkaline salts". Now free alkali, which undoubtedly fades Prussian blue, does not exist in the tissues or their juices. The inorganic salts of tissues and tissue-juices do not bring about any fading of soluble Prussian blue.

Ringer's solution added warm to Prussian blue produces no change of colour beyond that due to a corresponding dilution with water.

None of the salts of the tissues, NaCl, KCl, Na_2CO_3, $Ca_3 2 (PO_4)$, Na_3PO_4 in strengths under 1% solution added warm singly or in any kind of combination, caused any fading to the green or to the leuco condition, whereas the subsequent addition of such a reducer as pyrogallol at once caused fading through green to white.

When the gelatine and Prussian blue mixture is used to inject organs still living, the pigment is reduced, as I believe, by the agency of the living tissues; and histologists aware of this fading, attribute it to "contact with the alkaline salts of the tissues."

Thus Rawitz[16] recommends that a little acetic acid be added to the injection-mass to prevent the "fading" by alkaline tissues.

Naturally, this criticism applies only to pigmentary substances, and has no applicability to non-pigmentary salts used to demonstrate bio-chemical reduction.

(b)   The next source of fallacy one must bear in mind is the possible putrefaction of the proteins of press-juice in in specimens of juice kept for more than a few days.

Toluene was the antiseptic used for all press-juices; some kind of antiseptic is absolutely necessary, although Battelli[23] has emphasized the inhibitory effect of antiseptics on the enzymic and respiratory powers of tissues. The antiseptic used had obviously to be one which would not of itself bleach or reduce the pigments or other substances and would not act as an activator or inhibitant of the enzyme. Sodium fluoride and many other substances had to be rejected on some of those grounds. Toluene apparently prevented putrefaction in the press-juices used. Had the reductions in old juice (two to six weeks old) been due to putrefaction or autolytic substances, then the reducing power should have

steadily increased with the age of the juice. But exactly the opposite was found, the longer the juice was kept under toluene the *less* it reduced until after ten weeks or so it did not reduce at all. But putrefaction would have been progressive, and therefore reduction due to putrefaction would have been *more* marked as time went on. I had, however, positive evidence of the absence of putrefactive micro-organisms in a specimen of liver juice three months under toluene, which was examined for me by Dr. Sholto Douglas of the University of Birmingham and pronounced sterile.

It seems clear, then, that the reductions studied were not brought about by the products of putrefaction or autolysis.

(c)   As regards fallacies, another point to be remembered is that the substances employed—Prussian blue, ferric chloride, etc., are all more or less poisonous. We cannot, therefore, expect the living tissue to reduce unlimited quantities of such substances whether pigmentary or not.

Thus only the earlier portions of liquids emerging from perfused organs or being excreted into the gall-bladder or ureter should be examined for reduced material. Because a kidney perfused indefinitely long with ferric chloride does not continue to produce unlimited quantities of ferrous chloride is no evidence that it was not originally able to reduce some of it, for such substances, even in dilute solution, are more or less toxic to living protoplasm, especially in experiments in which that protoplasm is receiving no blood.

(d)   The last criticism is that of A. Heffter ([17]) which is directed not so much against the methods of judging of reduction by the fading of pigments, as against the whole conception of tissue-reduction being enzymic in nature. Heffter holds that the labile H of colloids in such a grouping as cystëine is able to effect all the reductions observed. He says that crystallized egg-albumen can bring about many reduc-

tions. Heffter's contention is that proteins apart from life can actively reduce.

Confining ourselves first of all to Prussian blue, it is certain that all proteins do not cause this pigment to fade, at least within times measured by hours and at room-temperature. For one thing, gelatine itself without acid does not cause soluble Prussian blue to fade even before it is injected into an organ and even when heated.

It is well known that this injection-mass mixed with the blood-proteins in the large vessels of mammals at body temperature is not reduced or caused to fade. Neither is methylene blue; those pigments remaining blue produce along with the red of the blood *a purple* colour. If Heffter be correct, we should expect the blood-proteins to reduce these pigments to a pale green or leuco condition, this they certainly do not do.

If one mixes a saline solution of *pure* serum-albumen or serum-globulin with Prussian blue, no fading takes place at room temperature within 24 hours.

In 1912 my co-worker at that time, Dr. H. J. M. Creighton[18] of the Dalhousie University, Halifax, N. S., investigated this subject with very great care and published his results in the Transactions of the Nova Scotian Institute of Science.

Dr. Creighton showed that if one mixes 10 c.c. of a 15% solution of egg-white in dilute NaCl with 10 c.c. of a 0.05% solution of soluble Prussian blue (potassium ferric ferrocyan_ ide) and keeps the mixture at 60° C the colour will have faded at the end of an hour. The fading is gradual. Dr. Creighton writes, "With pure white-of-egg at a higher temperature, the decoloration of the soluble Prussian blue was found to proceed with greater rapidity".   On the other hand, white-of-egg solution and 0.05% Prussian blue mixed and kept at *room temperature*, showed no fading or change of colour at the end of six hours.

Dr. Creighton further showed that the iron ion originally trivalent in the soluble Prussian blue is divalent in the

colloidal complex of albumen and the pigment. There has therefore⁻ been reduction. Further, this colorless colloidal complex⁻can be boiled for a short time without its coagulating. For convenience, I call these phenomena, "the Creighton effects". Now there is one significant difference as regards the interaction between proteins and soluble Prussian blue and the interaction between press-juice and that pigment, namely, that whereas there is no fading of the blue in the presence of protein at the end of many hours, the blue in contact with fresh juice fades *at once*. These are clearly not the same phenomenon; for one thing, in the case of the protein mixture the concentration of protein is very much greater than it is in press-juice, but its effect is very much slower.

Further, if the fading of the pigments is due to protein, then the juice kept for three months, in which the protein is well preserved and is sterile, should reduce as well or almost as well as fresh juice; but this is noticeably not so.

Again, the rapid falling off in potency as regards reduction within the first day would have no meaning as a phenomenon due to molecular groupings and labile hydrogen, whereas it has a meaning with reference to the deterioration of the biochemical activity of a ferment.

The fact that glycerol extracts of dried liver and of dried kidney possess some reducing power, is more in accord with the conception of that reduction being due to an enzyme than to a protein, for the glycerol extract of *dried* liver had some cognizable reducing power, and it could have taken up very little protein in "solution". Glycerol by itself has no reducing power.

Again, glycerol extracts deteriorate in potency with time for which there is no particular reason, if protein be the active substance. Blood at 40° C does not reduce ferric chloride, but liver-juice at this temperature reduces it to ferrous chloride. There are proteins in both. While giving due weight to Heffter's contentions, and indeed recognizing certain

phenomena of the fading of pigments in contact with proteins which I have called "the Creighton effects," I still believe that vital reduction is something distinct from these and is probably enzymic.

VII.   INDICATIONS THAT A TISSUE ENDO-ENZYME EXISTS

1.   The first consideration regarding reduction being due to an enzyme is that, whereas quite fresh juice vigorously and older juice more gradually reduces several different kinds of chemical substances, boiled controls do not do so at all.

2.   The behaviour of the juice in regard to temperature is the next point indicating the presence of an enzyme.

Its optimum is between 42° C and 46° C. Thus Herter found reduction processes were accelerated in the experimentally induced fever of hog cholera. As the temperature falls, the rate of reduction is diminished until *at zero* reduction is entirely *inhibited*. But at a temperature as low as minus 14°C, the reducing power is not destroyed; it is merely kept in check.

I have kept under observation a mixture of absolutely fresh liver-juice and Prussian blue, surrounded by a freezing mixture for 24 hours, without noticing the least degree of fading of the deep blue colour. On removing the tube from the freezing mixture, the colour was completely discharged by the time the juice had reached room-temperature (17°C).

Herter found in the intact animal that "the power of reduction was much diminished by cold."

A typical experiment may be quoted in connexion with temperatures.

Three water baths were brought to (a) between 40° and 41°C; (b) between 42°C and 43°C; and (c) between 44° and 45° C respectively. In each bath a tube was placed containing 3 c.c. of 24 hours old hepatic juice shaken up with 20 c.c. of Prussian blue all under toluene. In 6 hours the tube in (a) was green, that in (b) was green-white, the one in (c) was

quite white; twenty four hours later the tube in (b) was white. The behaviour of tissue-juice is compatible with its active constituent being an enzyme.

3.   As judged by the Pozzi-Escot test, a reducing ferment is present in certain tissues; for pieces of tissue, but better their juices, decompose pure H_2O_2 without affecting a mixture of guaiacum and H_2O_2.

That the press juice, for instance of liver, is more active than pieces of liver is in accordance with the findings of other workers on ferments.   J. J. R. MacLeod[20] noticed this in the case of glycogenase, an undoubted endo-enzyme.

4.   The reducing action is accelerated or augumented by the presence of alkaline salts of the tissues, which behave as adjuvants.   Professor Irvine and I[11] concluded that reductase acted after the manner of pyrogallol, an organic reducer, in an alkaline medium.

5.   In my recent work[21] on the action of protoplasmic poisons on reductase, I found that the acidity (concentration of H ions) was a more profound inhibitant of the reducing power than was toxicity.   Concentration of H ions is well known as an inhibitant of the activity of certain enzymes; to this reductase would not form any exception.

The fact that reductase is not totally inactivated by certain virulent protoplasmic poisons—chloroform, sodium fluoride, nitrobenzene, formalin—makes reductase comparable with the ferment in the laurel leaf studied by Dr. Waller[24]. Chloroform was found to kill the leaf, but to set free an enzyme which liberated HCN.

6.   As a ferment, reductase is pretty easily inactivated by drying the juice in vacuo at 15°C and by precipitation from juice by absolute alcohol.   As might be expected, drying and alcohol injure it less in tissues than in press-juice.

It clings with considerable tenacity to the cell-proteins, which evidently guard it from inactivation by heat, by drying and by alcohol.

In regard to its sensitiveness towards alcohol, reductase is in marked contrast with glycogenase, which can be obtained in an active state even from livers which have been for months under alcohol. This power that colloids have of protecting enzymes is a well-known property of the relationship between these two classes of bodies.

As judged by the criterion of solubility, reductase is comparatively insoluble; it will not, for instance, dialyze away from the cell-proteins. But in that it can in some measure pass into solution in dilute glycerol, it cannot be regarded as entirely of an insoluble nature

The insoluble endo-enzyme is now fully recognized. Professor Adrian Brown tells me that phyto-enzymes of a non-soluble order exist, and according to Vernon[22] the oxidase of the liver is insoluble. He adds that its insolubility does not preclude its enzymic nature, as there is a good deal of evidence pointing to a similar property in some lipolytic enzymes.

VIII. Remarks on Tissue Respiratory Ferments.

Besides reductase, at least two other types of respiratory enzyme exist in the liver, to confine our attention only to the liver in the meantime, namely a catalase and an oxidase or a number of oxidases. A catalase has long been recognised in the blood and tissues;   Creighton and I[25] recently wrote:—

"The existence of a catalytic enzyme in the mammalian liver is fully confirmed. The decomposition of H_2O_2 is effected by this enzyme, and is not due to the presence of proteins or other organic matter in the press-juice."

Boiled juice gives rise to no decomposition of H_2O_2; and the amount of H_2O_2 decomposed bears no relation at all to the amount of protein in the juice, for a few drops of a very dilute juice reduced 97.2% of H_2O_2 in the first five minutes. No doubt it is possible that the two enzymes, catalase and reductase, may co-operate in hepatic reductions.

The presence of an oxidase, more probably of oxidases, must be remembered when one is working with the reducing ferment. As Dr. Vernon has shown, there are oxidases in the liver which must of necessity work in the direction opposite to that taken by the reductase.

Hence when we obtain a less distinct reduction than we expect, we have to remember that the oxidase may have been active. We have, in fact, the converse of the difficulty to which Dr. Vernon[14] alluded when, investigating "The quantitative estimation of the indophenol oxidase of animal tissues", he wrote: "The unavoidable presence of reducing substances, some of which are possibly enzymes or reductases which act in direct antagonism to the oxidases, and under certain conditions entirely overpower them. Hence the absence of an oxidizing action cannot be held to indicate the absence of oxidase unless the conditions are so chosen to give the oxidase the best possible chance of exerting its activity."

At an early stage I had noticed that in a tube in which the Prussian blue had been completely reduced to the leuco state, a re-establishing of the colour was evident from about the end of the first week onwards. A mixture of fresh liver-juice shaken up with pigment of suitable strength would begin to become blue again in spite of the fact that the mixture was covered by a layer either of toluene or of oil to the depth of an inch.

In the routine observations, I made no attempt to eliminate the oxidase of press juice, but in one experiment Dr. Lovatt Evans and I definitely arranged to exclude the physiological activity of that ferment. Accordingly we kept a sealed up mixture of liver-juice and Prussian blue at room temperature under an atmosphere of pure hydrogen in a completely reduced state for three and a half months. It never showed the slightest re-blueing; on breaking open the tube and adding H_2O_2 the contents immediately became bright blue. Exposure to the air produced the same result more slowly. Evidently the activity of the oxidase was prevented expressing itself owing to there being no oxygen for it to deal with.

According to Spitzer, the vigour of oxidase declines post mortem, whereas that of reductase increases for a time, but it is possible that the former phenomenon is the cause of the latter, the increase in the energy of the reductase being only apparent and due to the diminution of that of the oxidase working in the opposite direction.

Dr. Vernon, ([14]) fixing his attention on the tissue-oxidases, regards reducing ferments as troublesome intruders into his experiments. I, however, am forced to recognzie oxidases as forming as much a part of the cellular, respiratory, enzymic mechanism as are reductases.

It is in this connexion significant that the Cannizzaro reaction—the simultaneous oxidation and reduction of aldehydes—has been observed most frequently with liver tissue in the presence of dilute sodium bicarbonate and oxygen.

Possibly the "aldehydemutase" of Parnas is not one enzyme but a mixture of oxidase and reductase([23]).

In some manner with which we are far from being fully acquainted, catalase, oxidase and reductase are all acting simultaneously in the living cells, carrying on the work of tissue-respiration. I have eliminated the activity of the oxidase for a sufficiently long time to allow the reductase untramelled activity; and conversely Dr. Vernon in his studies on oxidase has had to make due allowance for the presence of reducing substances.

Dr. Vernon and also Prof. B. Moore([25]) have pointed out several respects in which oxidase differs from reductase.

It is perhaps too soon to formulate any theory of tissue respiration, but when the scheme is outlined it must be one taking cognizance of all the three respiratory types of enzymes and not a scheme framed in terms of oxidase alone.

Provisionally one might say that by reductase, oxygen is abstracted from tissue-lymph (more remotely from oxyhaemoglobin) and brought within the sphere of the activity of the oxidase which applies to it the oxidation of the carbon, hydro-

gen, sulphur, phosphorus, etc., in, or in the neighbourhood of, the living protoplasm.

With regard to haemoglobin, I have direct evidence that liver-juice can reduce this pigment from the fully oxidized two-banded condition to the fully reduced one-banded within a few minutes at 41°C. The quantities used were a test-tube full of solution of oxy-haemoglobin from freshly drawn defibrin-ated rabbit's blood, and three grams of freshly disinte-grated liver squeezed before the animal heat had left it. This mixture was shaken up from time to time to distribute the juice, and within a minute or two, the solution had begun to lose its brightness which it steadily continued to do. The two bands in the spectrum became progressively hazier until at within ten minutes they had disappeared and been re-placed by the single band of haemoglobin; shaking this pigment at once made the two bands re-appear; it was, therefore, reduced but still oxidizable.

A control, similar in all respects except that the juice was *boiled* for five minutes, showed no signs of being reduced at the end of 72 hours. This solution never did become reduced, but passed normally into the state of methaem-oglobin.

A period of ten minutes may seem a long one in which to have to wait for reduction to haemoglobin, but we must re-member that in vitro we have the entire mass of the solution finally fully reduced, while in vivo we never have the oxy-haemoglobin fully reduced in consequence of contact with the living tissues during only one transit of the blood. The blood is fully reduced only after the many transits in asphyxia.

I think, then, that we are justified in regarding the reduc-tase as the respiratory ferment of the living tissues, the endo-enzyme, through whose reducing power oxygen is split off from the oxyhaemoglobin in the several capillary districts

It would seem to be the ferment which starts the process of internal respiration, oxidase that which continues and completes it.

IX. THE CHEMICAL POWERS OF REDUCTASE.

In conclusion I should like to point out the true reducing character of the reductase of animal tissues.

(a) In the first place it is a typical deoxidizer in that it removes oxygen from osmium tetroxide and from such substances as oxyhaemoglobin, which is fully reduced, and methaemoglobin, which is reduced to the oxy condition.

(b) Substances containing oxygen, but not in a form wholly removable, can be reduced from the higher to the lower state, as when sodium nitrate is reduced to sodium nitrite,[25] or when sodium indigo-disulphonate and sodium alizarine-sulphonate are respectively reduced to their pale chromogens.

(c) The reductase can also reduce metallic salts containing no oxygen from their higher to their lower forms, as when ferric chloride is reduced to ferrous chloride[15]. Here the change involved is the removal of an ionic charge from the trivalent ferri-ion which becomes the di-valent ferro-ion.

(d) Finally, certain pigments containing no oxygen such as soluble Prussian blue and methylene blue are reduced to the pale or white chromogenic conditions of the di-potassio-ferrous-ferrocyanide and methylene white respectively.

In all these reductions, the endo-enzyme is behaving after the manner of an inorganic reducing agent in an alkaline medium.

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Senecio Jacobaea and Callimorpha Jacobaea (the *Cattle Killing Ragwort and the Cinnabar Moth*) By Henry S. Poole, D. Sc., Guildford, Surrey, England.

Some sixty or more years ago a plant strange to Nova Scotia, known as St. James Ragwort, Ragwort, Baughlan, Staggerwort, and Stinking Willie, was noticed growing at Merigomish and to be spreading over the neighborhood. Its seeds were supposed to have come in the ballast of timber ships. The speculations as to its origin when first noticed gave place in the course of time to invidious references more and more pronounced as the plant spread and invaded pastures and hayfields, scattering its seed freely in the Fall in total disregard of the spasmodic endeavors of farmers to extirpate it. It is included in the "Farm Weeds of Canada" by G. H. Clark and James Fletcher of Ottawa, 1902, and is spoken of as a noxious weed imported into Pictou county, Nova Scotia, whence it has spread in the course of years to other parts of the Province. Dr. A. H. MacKay in the Journal of Education for Nova Scotia, 1908, dwelt at length in his earnest endeavors to incite through the public schools, the farmers and their children in the infested districts, to a crusade against the plant. Prizes were given and he says millions of the seed were destroyed. The effort to exterminate it by this means, was, however, found ineffectual and consequently abandoned. Any steps that have since been taken to check the spread of the plant have been those of individuals on their own lands only. The roadsides, the burnt lands and the unenclosed woodlands have been left to the undisturbed possession of Stinking Willie.

In England, Ragwort is referred to in "Common Weeds of the Farm and Garden" by Harold C. Long, and in Weeds of the Farm and Garden" by Pommel. In these works and in ordinary life any reference to the plant is in mild terms. It is spoken of merely as one of the many weeds of the roadside, as a common weed and nothing more. It has been left to Nova Scotia to single it out for notoriety by a specially opprobrious name and for reference to its noxious character on the floors of the local parliament.

To botanists it is an interesting member of the Compositae with discal florets of thirteen rays.

To me, a native and long a resident of Pictou county, thoroughly familiar with its luxuriant growth and its objectionable characteristics, it came as a surprise to meet with Ragwort comporting itself as a modest weed on the commons and heaths of Surrey in small communities and often solitary. I met it first in company of a botanist, Mr. H. E. Lee, and to him I contrasted its unobtrusive deportment in England with its assertiveness in Nova Scotia where it takes more than its fair share of place in the sun and in the waste places of Pictou county.

I aroused Mr. Lee's interest by telling him of the burnt lands and the fence rows yellow with its golden blossom in Autumn and of the ineffectual attempts through the public school teachers to root it out and exterminate it, or at least to check its spread to other parts of the Province. I mentioned also, that, however effective might be a rotation of crops in the cultivated ground and the indiscriminate grazing of sheep in the pastures, the unenclosed deforested land was so large that all hope of extirpation by the hand of man and the teeth of sheep had to be abandoned. It was then he told me Ragwort had a natural and special enemy in the Cinnabar moth whose showy colouring had previously attracted my attention. This information at once suggested that if the fact as stated to me was sustained on further inquiry and the

knowledge proved to be as new to the Canadian agricultural authorities as it was to myself, then it would be worthy of further investigation.

To this end I spoke to the Director of the Royal Botanic Gardens at Kew, Sir. E. D. Prain, and to officials in rooms four and eight of the Department of Agriculture and Fisheries, Whitehall Place, and also to Mr. R. South, F. E. S. of the Natural History Museum, South Kensington. In the meantime I had made acquaintance with Mr. I. W. Walton, the botanist, at Folkestone, who confirmed from local observation the statement made by Mr. Lee. Any lingering doubt I may have had was removed on visiting the Natural History Museum and reading the slip attached to the specimens of *Callimorpha Jacobaea*, the Cinnabar moth of the order Heterocera.

Seeing that none of the works on weeds already quoted made reference to the Cinnabar moth, attention was turned to Barret's Lepidoptera of the British Isles, a standard work, and on page 246 the moth is spoken of as common in England and as having been taken as far North as Perth. It was also mentioned that while the moth is generally met with on Ragwort, it has occasionally been found feeding on the Coltsfoot.

At this stage of my inquiry several questions presented themselves: among them first, was the Cinnabar moth known in any part of North America?

Inquiry of the Bureau of Entomology, Department of Agriculture, Washington, U. S. A., brought a courteous reply from Dr. F. H. Chittenden to the effect that he has never found *Callimorpha Jacobaea* to occur in the United States at all; and he further wrote that on referring the matter to Dr. H. D. Dyar a specialist on Lepidoptera in that group, he stated that he has never known of its being taken in the United States.

This reply suggested in turn a second question—might the Cinnabar moth if introduced into Canada become as disastrous an importation as the gypsy and brown-tailed moths had proved to be? I referred this question to Mr. South of the Natural History Museum, and he had no hesitation in saying he saw no reason to dread the introduction of the Cinnabar moth. It was not of a class to become a pest as the narcissus fly or the larch saw-fly. He further permits me to quote him and to refer to him if need be.

A third question that presents itself is—what are the prospects that the Cinnabar moth will, if introduced into Nova Scotia, to establish itself there? To this, all that can be said without actual trial is, that the moth survives in the climate of Perth in a latitude far to the north of Pictou. Then it may be asked if the moth should be found to stand the climate of Nova Scotia, is there a probability of its abandoning its European predilection for Ragwort and taking to feeding on other allied species of plants?

About the time that Ragwort established itself at Merigomish, cases of hepatic cirrhosis occured among cattle of the same district. This was a new disease, entirely local, that yielded to no known treatment. Current belief imputed the disease to the weed but up to the end of the last century investigations had failed to establish a connexion. As the weed spread and flourished in new ground so did the disease range over a widening area from new centres of virulence.

These new centres were in some cases places where the weed had been growing for very many years without an occurrence of the disease, or if there was a case, it was a solitary one, which inquiry showed had lately come from an infected locality. Since the present century came in the spread of the disease seems to have been more rapid, and in remote districts beyond the height of land that isolated, as it might be said, the primarily infected area.

Ragwort being a biennial has no chance of flowering and seeding in the pastures grazed over by sheep which are close

croppers, and are in consequence a check on the spread of the
weed in enclosed lands. Horses too, are not known to be
affected by it for they not only avoid it in the field but also
where they find it in the hay. Cattle, on the other hand,
while more discriminating in their feeding than sheep, are
careful to avoid eating it in the open but they have not the
same opportunity for rejecting it when it is dried and mixed
with hay in the byre. It is then they suffer, and it is now
stated on page 161 of "The Farm Weeds of Canada" that
Dr. Pethick of Antigonish has proved that Ragwort is the
cause of the Pictou County Cattle Disease. This being so it is
all the more apparent that trial should be made of any means
that may reasonably be expected to further check the spread
of so noxious a weed in Canada.

When commenting to me on the relation of Ragwort with
the Pictou County cattle disease Sir. E. D. Prain related an
Indian experience that was apposite to the matter. Speaking
of the use of sorghum as forage when the plant was fully
grown and cut down, he remarked that care was necessary to
keep cattle from the fields while the plant was still young as it
then contained hydrocyanic acid in poisonous quantity. Not
so when the sorghum was well grown, but it sometimes
happened that the season was wet after the harvest and then
instead of drying, the plant sent up fresh shoots which were as
poisonous to cattle as the young plant.

It would have been superfluous and presumptuous on my
part to dwell on the relation between the Cinnabar moth and
Senecio when so great an authority as the Natural History
Department of the British Museum accepts it without reser-
vation.

Mr. C. W. Brachen, B. A., F. E. S., of Plymouth writes
me as follows:

"I have met the larvae of the Cinnabar moth, when
sweeping, for years, but only on Ragwort and Groundsel
(*S. vulgaris*). I have never seen it on Coltsfoot. It can be

found in hundreds in Turnchapel Quarries, Plymouth, at Newton Ferrars, Hessenford, everywhere round here probably. I have found it more common near Ragwort though I have made no special comparisons."

Larvae of Cinnabar Moth (*Callimorpha Jacobaea*).

Food Plant: Commonly, the Ragwort (*Senecio Jacobaea*).

The larvae usually attack the lower leaves first and work upwards towards the flower. They frequently strip the lower portion of the plant completely, and in a very short time. Large colonies are often seen on one plant; and the striking colouring of the larvae make them conspicuous even at a little distance.

REMARKS BY DR. A. H. MACKAY.

Senecio Jacobaea L. (St. James Ragwort), was probably introduced into Pictou, Nova Scotia, not far from 1850. Shortly after, the Cattle Disease appeared. But it did not follow the presence of the weed until after it became well established in the pastures and hayfields. About 1882 there was an attempt made by the Dominion Government to ascertain the character, cause and best method of dealing with the disease which was recognized as a peculiar and almost specific cirrhosis of the liver. It was, however, suspected to be contagious; and the policy of slaughter and compensation was adopted. Drs. William Osler, Adami, Wyatt Johnson, McEachran and other pathologists took part in the earlier investigations.

In 1906 Dr. J. G. Rutherford as Veterinary Director General, reports Dr. W. H. Pethick's experiments on a 200 acre farm at Cloverville in Antigonish county. He also notes that Dr. Gilruth of New Zealand devoted considerable attention to a peculiar hepatic cirrhosis known as the Winton Disease, from which horses as well as cattle and sheep suffered due to the ingestion of Ragwort. In Cape Colony, South

Africa, *Senecio Burchelli* appeared to produce similar effects. Last year another species, *Senecio latifolius,* in South Africa appeared to have poisonous properties according to the kind of soil in which it grew. Dr. Pethick's experiments appeared to prove that the disease is not contagious, and is due to the ingestion of the Ragwort with hay eaten.

Professor Arthur R. Cushney of the Pharmacological Laboratory, University College, London, England, lately experimented with the Senecio alkaloids and makes the following statements in two papers published in 1911.

1. "On the Action of Senecio Alkaloids and the causation of *Hepatic Cirrhosis* in Cattle (Preliminary Note)" Read 15 June, Proceedings Royal Society B. Vol. 84; and

2. "On the Action of Senecio Alkaloids and the causation of the *Hepatic Cirrhosis* of Cattle (Pictou, Molteno, or Winton Disease), published 10 June, in the Jour. of Pharmacology and experimental Thearapeutics, Vol. II, No. 6. July, 1911.

(1). "The various species of Senecio in this country are generally regarded as harmless, the chief of them being the common ragwort and the common groundsel. In Nova Scotia, New Zealand, and South Africa they have, however, been associated with hepatic cirrhosis in cattle, which is known as respectively Pictou, Winton, and Molteno disease in these countries. The species which induces this condition in Canada and New Zealand is apparently identical botanically with the common ragwort of this country, *Senecio Jacobea*, while in South Africa the Molteno disease is associated with the *Senecio Burchellii* and the *Senecio latifolius*. The symptoms of the disease are practically identical in these locations."

(2). "With regard to the chemistry of the *Senecio* genus, Grandval and Sejour found two alkaloids in the common groundsel which they term senecionine and senecine, and Watt found two others in the *Senecio latifolius* of Cape Colony,

and has named them *senecifoline* and *senecifolidine*. These
alkaloids amounted to 1.72 per cent. of the plants in the crude
state before flowering, and 0.76 per cent after flowering.
These two bases were sent to me for pharmacological examin-
ation by Prof. W. R. Dunstan, and I have done a number of
experiments with them, chiefly upon cats."

(3). "The symptoms and post mortem findings in
animals poisoned with these alkaloids resemble so closely
those described by Gilruth, Chase, Pethick and others, in
cattle and horses, that there can be no question that the cause
is the same in each and that the Pictou, Winton or Molteno
disease is really more or less chronic poisoning with the
Senecio alkaloids."

(4). "The experiments hitherto detailed were performed
with the alkaloids of *Senecio latifolius,* which, as has been said,
is held responsible for some of the epidemics in South Africa;
and my results indicate that these alkaloids are capable of
inducing the symptoms and lesions characteristic of the
disease. The *Senecio Jacobœa* which has been shown to be
responsible for the disease in New Zealand and Canada, grows
in profusion in England and Scotland, but inquiries made in
various parts of the country indicate that poisoning with this
plant and hepatic cirrhosis are unknown here."

(5). "These results would therefore seem to indicate
that the *S. jacobaea* is devoid of the toxic properties of *S. lati-
folius,* whether the plant is grown in England or in Canada.
This is however incompatible with the results of Gilruth and
Pethick, who showed definitely that the disease in Canada and
New Zealand is due to this species. The discrepancy between
these results and mine may probably arise either from the
plant from which my preparations were made having been
collected at the wrong season, or possibly from the poisonous
principle having undergone change into some inert form in the
course of preparation or drying."

(6). "*Senecio sylvaticus* collected in Yorkshire in August proved equally inactive. *Senecio vulgaris* or common groundsel collected in England and prepared in the same way proved poisonous."

(7). "I hope to investigate further the toxicity of *S. jacobaea* with the hope of elucidating the curious discrepancies between my results and those of Gilruth and Pethick."

(8). The following statement has just been made by Professor Cushney in an autograph note on one of the said printed papers in October, 1913. "Later experiments with the alkaloids derived from the *S. Jacobaea* grown in Canada have shown that they are quite as poisonous as those obtained from *S. latifolius*" (Oct. 1913).

The weed is rapidly spreading throughout the Province, and the appeals to municipal councillors have not yet incited any effective action. Sheep are not so seriously affected by the plant; but there is evidence that it is injurious to them. The plant grows luxuriantly and, although it is popularly known as "Stinking Willie", it is one of the most beautiful of our weeds, the abundant pretty green foliage being surmounted by a brilliantly yellow flat-topped cluster of compound flowers.

If the Cinnabar moth could repress the luxurious growth of *S. Jacobaea* in Nova Scotia, it would require to multiply rapidly and feed ravenously.

But, what if the larvae of *Callimorpha Jacoboea* should take to feeding upon the plants of economic value? What if they should develop here as the Gypsy Moth and the Brown Tail? The English Sparrow first introduced about 1850 has long become too vigorous for America. The European rabbit introduced into ·Australia in 1864 for sport, increased so rapidly as to require legislation in 1879 for its destruction. The Mongoose of India introduced into Jamaica in 1872,

by 1890 became a pest. The European Starling introduced into New Zealand in 1867 in a few years began to show itself as an undesirable. The skylark, the linnet and the blackbird of England, have in the antipodes developed new food habits, and instead of being insect destroyers as at home, are becoming fruit pests.

Can we therefore venture to invite the Cinnabar Moth to Nova Scotia? Test the new conditions might develop a taste for something more than the succulent foliage of St. James Ragwort.

THE GEOLOGY OF A PORTION OF SHELBURNE CO., SOUTH WESTERN NOVA SCOTIA.—BY SIDNEY POWERS, *Geological Museum, Cambridge, Mass.*

INTRODUCTION.

This paper represents the results of a brief geological reconnoissance along the shore of Southwestern Nova Scotia from Jordan Bay to Barrington Passage, made during June 1913. The object of this reconnoissance was to study the structural geology, but outcrops were found to be few in number, and to be practically confined to the wave-beaten ends of the peninsulas, and therefore the work was not extended farther. As the only detailed previous examination of the region was made by Dr. L. W. Bailey in 1891 to 1896*, it is thought that this paper may form a contribution to the knowledge of the region. The structural details and the petrography of the igneous rocks were not considered in Dr. Bailey's report.

The general geologic features of the region consist in a series of pre-Cambrian metamorphic quartzites and schists intruded by Devonian granites which have produced extensive contact metamorphism in the already regionally metamorphosed and folded sediments. Glacial deposits now cover the surface allowing the geologist only an occasional glimpse at bed rock.

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* Report on the Geology of Southwestern Nova Scotia; Canadian Geological Survey, Ann. Rept. Vol. 9, Pt. M, 1898.

LEGEND

DEVONIAN

[×] GRANITE

PRE-CAMBRIAN

[ ] SCHIST

[ ] QUARTZITE

———— Faults

A———B Sections
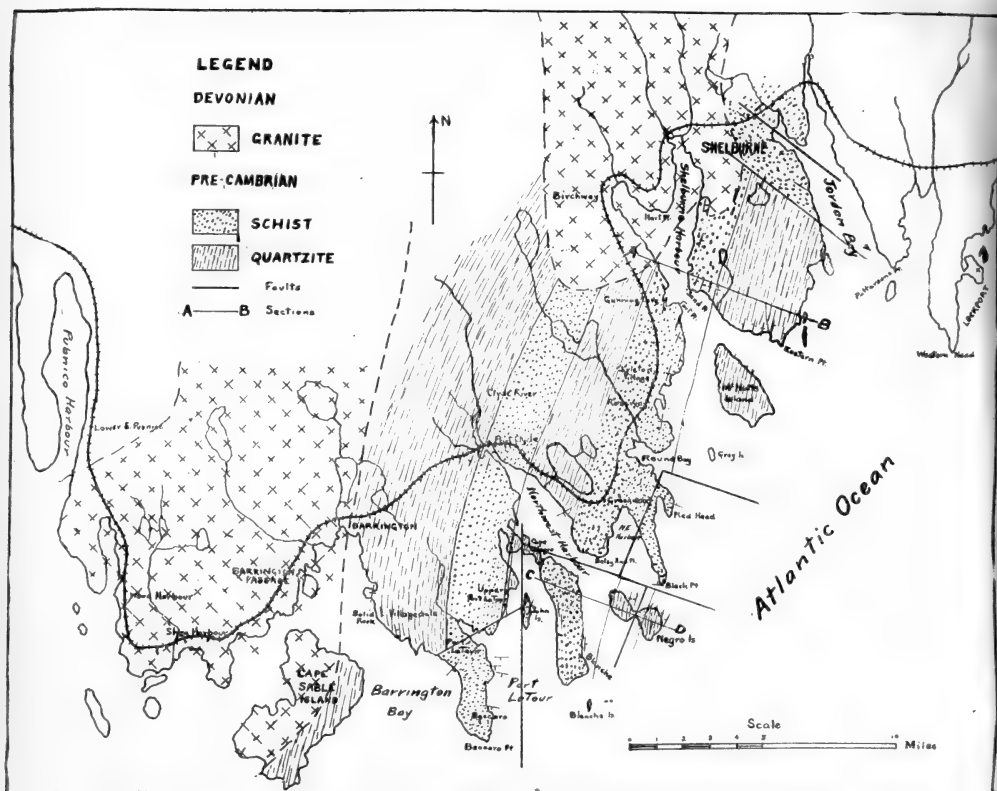
PHYSIOGRAPHY AND GLACIAL GEOLOGY.

Southwestern Nova Scotia is a low, rolling country indented by an embayed shoreline. Numerous lakes, often of large size, and more numerous peat bogs representing former lakes cover the low-lying areas. Where these are absent, boulders characteristically cover the land, representing the ground moraine. Such a topography determines the occupation of the inhabitants of the country, preventing agriculture and promoting fishing and boat-building. The low hills are covered by a dense, but low, forest of spruces and balsams which effectually conceal the view. Frequent forest fires, due to the carelessness and wilfulness of the inhabitants,

prevent the growth of mature forests and leave in their wake a scene of desolation—burned villages and square miles of charred tree trunks laying bare the boulder-strewn ground moraine.

The present topography of the region is due to the dissection and drowning of the Cretaceous peneplain and to glaciation. The peneplain was uplifted probably toward the middle of the Tertiary and suffered erosion throughout the remainder of the Tertiary. The land during this period appears to have stood higher than at present, long valleys being formed which are now drowned. These valleys were formed without respect to geological structure because the rocks have about a uniform hardness and have been sufficiently metamorphosed to obliterate the primary structure and yet not to produce pronounced cleavage. The submergence of the land to its present level took place at about the time when the Pleistocene ice sheet advanced over Nova Scotia. The submergence did not go below present sea level because there are no marine beaches or wave-cut terraces above those being formed at present. In the Bay of Fundy region there is evidence of a recent uplift as is shown by the presence of marine fossils in beaches 200 feet above water level. It is therefore evident that there has been a differential uplift of the land in the latter region. This tilting must have been at least as great as two feet to the mile, as it is 108 miles from Shelburne to St. John where the elevated beaches are found.

The effect of glaciation has been to modify the topography. Glacial erosion can be measured in at least tens of feet, for everywhere the pre-Glacially weathered rock has been removed, and the bed rock scoured and channeled. Roches moutonnées are very frequent where wave action has removed the glacial deposits. These rounded knobs are especially noticeable at Port La Tour, forming islands at the entrance to the harbour.

Glacial deposits, other than the ground moraine, are largely of stratified drift. Eskers are the most striking phenomenon, but kames are also present. The character of the deposits must depend upon the kind of material with which the ice has to work. In the peninsula of Nova Scotia are soft Triassic sandstones and hard traps, developed only in a narrow band; fossiliferous Lower Devonian shales; and pre-Cambrian quartzites, slates and schists; the latter two series being invaded by the micaceous granitic rocks which form the central axis. The Triassic and Lower Devonian sediments would not furnish material for distant transportion and the traps would suffer little from glacial erosion. Therefore, for Shelburne County there was available a large quanity of sand derived from the granite and quartzite, and some sand and clay from the schist and slate, as well as massive material of each of these rocks. Hence, the ground moraine in this region is composed almost entirely of sand and boulders, drumlins being absent. Large deposits of sand are found at Villagedale, south-east of Barrington, forming numerous sand dunes 30 feet in height. The grains of sand consist largely of quartz with some pink feldspar, muscovite, and biotite, showing that they were derived from the granite nearby. Sandplains do not occur.

Eskers were observed at Shelburne, Roseway, Cape Negro and Port Clyde. The esker in Shelburne extends from near the Shelburne House in a N 10° E direction for about 1,000 feet. Its height varies from five to fifteen feet. Boulders and gravel appear on top of the ridge, the boulders having a length of two to three and a half feet. Near Roseway there are several eskers running nearly due south, the most prominent one being near the shore. This esker is about one-quarter of a mile long, 25 feet high and 75 to 100 feet wide. It forks at the south into two ridges. On the top of the esker are boulders 4 feet long, 3 feet wide and 3 feet thick. North of Port Clyde are abundant eskers, some of which have an east-

PLATE I.

View of Shelburne Harbor and Sand Point taken from Fort Point. In the distance, on the left, is the lighthouse on Sand Point and beyond it is Shelburne. The peneplained hills in the distance rise to an elevation of 200 feet. In the foreground is a glaciated ledge of staurolite schist whose bedding strikes toward Sand Point. The two erratics on the roche moutonnée are Shelburne granite. One has been almost quarried away—the usual fate of erratics in this country.

west elongation.   North of Cape Negro is an esker two miles long with the main highway running on the crest.   It runs across a swamp in a north-south direction, turning S 10° W at the southern end.   In one place the ridge disappears for 50 feet, and in another it divides to pass around a kettle hole 100 feet long and 60 feet wide.   At the south end it apparently expands into a poorly defined gravel plain.   Another esker connects Cape Negro with the Blanche peninsula.   Here again the road follows the esker ridge for three-quarters of a mile.   The esker is 5 to 25 feet high and 50 to 100 feet broad. Northwest of Baccaro Point is an esker crossing a marsh, with a road on its top.   This esker runs in a southerly direction for half a mile with a height of 20 feet and a width of 60 feet.

Everywhere in Shelburne County boulders are to be found. The largest are west of Shelburne.   At the side of the railroad here, may be seen granite boulders 35 feet long, 25 feet broad and 20 feet high.   This size of boulder is not infrequent, but more abundant are somewhat smaller ones, 10 to 25 feet long, lying not far apart, yet not forming a boulder moraine.   To emphasize the size of the boulders, it may be stated that all the granite for the two story granite post-office building in Shelburne was quarried from a single one.

In the region between Barrington and Roseway, which was burned over in August 1911, boulders about two feet in length are everywhere scattered over the surface, as abundantly on the eskers as elsewhere.   They are composed principally of the kind of rock found nearby.   It is everywhere characteristic of these boulders to have rounded surfaces, and yet not to evidence distant transportation.   Only one boulder was found of a rock not represented in the area by a closely allied type.   This was a diorite found north of Gunning Cove.

The direction of ice movement in the region was, judging from the striae, in a S 10° E direction in general.   The striae

noted are: in the vicinity of Sand Point and Fort Point (opposite Sand Point) N-S to N 5° W; a mile east of Greenwood N 5° W; at Black Point N 15° W; Negro Island N 8° W with an apparently earlier set of striations in one place of N 40° W; a mile north of Blanche N 10° W; near Port La Tour N 27° W; near Baccaro N 12° W to N 27° W; near Baccaro Point N 25° W and one outcrop N 40° W; at Barrington N 12° W.

Sedimentary Rocks

The southern and western portions of Nova Scotia are largely underlain by a series of quartzites, slates and schists, called the Meguma or Goldbearing Series. The age of these rocks is pre-Cambrian. The series has been divided lithologically into two conformable formations, the quartzite division at the base being called the Goldenville formation, and the slate above, the Halifax formation. The thickness of the former has been found by Faribault to exceed 23,700 feet, and the thickness of the latter is 11,700 feet, giving a total thickness to the series of nearly 7 miles with no base exposed.

In Shelburne County these two formations are represented by quartzites, some of which show the effects of contact metamorphism, and by schists, all of which are filled with metamorphic minerals. The exposures are so few and the faults so numerous that it is impossible to measure the thickness of the series. Their general distribution may be seen on the accompanying map.

The first exposure of the metamorphic rocks south of Shelburne is found on the shore halfway to Sand Point. Very fine-grained grey mica schist cut by aplite veins occurs here within a short distance of the granite. Approaching Sand Point, staurolites and large mica crystals begin to appear in the rock. At the point are large ledges and roches moutonnées of a lustrous schist containing numerous staurolite prisms a quarter of an inch in length, very abundant smaller biotite crystals all orientated parallel to the schistosity, and very

small garnets. Certain harder places in the surface of the rock stand up as small rectangular pinnacles one inch in diameter and three to four inches high, undercut below the hard capping which is only one quarter of an inch thick. The top of these caps are remnants of the smooth surface left by the ice. Such deep post-Glacial erosion is favored in this locality by the soft nature of the sericitic ground mass of the schist. The strike of these rocks averages N 25° E with a dip of 75° S.

A half mile east of Sand Point the schist is replaced by quartzite of light grey color and fine grain in which are occasional quadrangular biotite crystals about one quarter of an inch on a side (perhaps secondary after hornblende), staurolite crystals one half inch long, and occasional pink andalusites one inch long. The dip of the beds changes from 70°-85° S to vertical.

For a mile to the south much of the quartzite does not show large metacrysts*, though small biotites still persist. At one locality a mile and a half south of Sand Point, staurolite-biotite quartzite reappears. The staurolites are of usual size, but few in number. The biotite metacrysts are about one-sixteenth of an inch in length. Under the microscope the rock shows a fine ground-mass of quartz and sericite, meta-crystals of biotite free from quartz inclusions, a few garnet crystals, and accessory chlorite, apatite and iron ore. The sericite is more abundant near the biotite than elsewhere. The strike of these rocks is N 15° E, the dip 75° N.

From the outcrop just described to the end of Eastern Point, the rock is everywhere a dense grey quartzite free from metacrysts. Interbedded in the quartzite are a few bands of mica schist one to three feet wide. The structure here is anticlinal, the dip of the bedding being vertical near the "Tea Chest", a mile and a quarter north of Eastern Point with a dip of about 75° N on the north, as above stated, and

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*A term introduced by Lane to designate the phenocrysts of metamorphic rocks which are formed after the groundmass. See the Bull. Geol. Soc. Amer. Vol. 14, 1903, p. 369.

a dip of about 80° S on the south. The strike is persistently N 15° E. The southern limb of this fold has been traced on the southwest through McNutt's Island and on the northwest through the towns of Lower Jordan Bay and Jordan Bay, but north of here a fault apparently cuts off the beds, as the strike changes to N 70° W and the dip to 40° N.

The structure of the peninsula is interpreted as a syncline in the schists on the north and an anticline in the quartzites on the south as shown in the section, Fig. 1. The pitch of the axis of the syncline is about 70° S. The syncline is cut off on the north by the granite, and the southern flank of the anticline disappears under the sea. On the opposite side of the Jordan fiord, Bailey found a few outcrops which indicate an anticlinal axis running in a N 60° E direction and starting about a mile north of Patterson Point. This anticline is separated from the one at Eastern Point by a northwest-
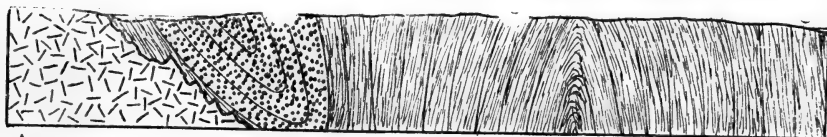
A   B
(Fig. 1.)   Section through Sand Point and Lower Jordan Bay

Devonian   Pre-Cambrian
[granite symbol] Granite   [schist symbol] Schist   [quartzite symbol] Quartzite

southeast fault, and between these two large segments, on the north, there appears to be a block about two miles wide with a monoclinal dip at a rather low angle in a N 20° E direction. It is worthy of notice that at Western Head, 6½ miles east of Eastern Point, Bailey found a quartz pebble conglomerate and ripple marks in the quartzite (op. cit. p. 56).

On the west side of Shelburne Harbor, the first outcrop south of Birchtown is of quartzite, free from metacrysts, at Gunning Cove. The strike is N 10° E, dip 55° S, indicating that this quartzite is folded up on the north limb of the syn-

cline seen on the other side of the bay. It is noteworthy that this outcrop is within two miles of the granite, but shows no development of contact metamorphic minerals, owing probably to the dense texture and low alumina content of the rock. From Gunning Cove to Red Head (south of Round Bay), staurolite schist occurs in which the staurolites are of large size (one inch long), but not very abundant. The strike remains about the same, the dip being at a high angle toward the south until it changes to 75° N, east cf Round Bay, on the southern limb of the syncline.

At Red Head staurolite schist outcrops, the staurolites being more abundant and of larger size than anywhere else in the region. Abundant biotites and small garnets are associated with the staurolites, and bands of the rock contain only biotite metacrysts. The strike is due E-W, and the dip at 3° N. indicating an east-west fault north of here. The same strike and a 10° N dip of the bedding is found at Black Point, three miles to the south. Here, also, the staurolites are abundant.

Negro Island consists of two islands joined by a sand bar. On the north shore of the eastern island staurolite schist appears on the west, near the lighthouse, and quartzite free from metacrysts on the east. The strike is about N 30° E with a variable dip of 15°-40° N. On the western island quartzites, locally containing a few staurolites, outcrop with a strike N 15° E, dip 70°-85° N. There is evidently a fault between the islands with a downthrow on the east, and also an east-west fault between the islands and the mainland.

On the mainland near Betsy Ann Point (separating Northeast and Northwest Harbors), a spotted grey ottrelite schist appears, with a strike of N 25° E, dip 30° N. It is a continuation of the southern flank of the syncline which has been traced from Sand Point. A fine-grained garnetiferous schist occurs a mile to the northeast and micaceous quartzite a mile and a half to the northwest. The same structure probably

continues into the Blanche peninsula, where mica schists with small garnets and occasional staurolites outcrop at Blanche and on the western side of the peninsula. In both places the strike was within a few degrees of due N-S, and the dip in the latter case 33° E. It is probable that the axis of an open syncline underlies Blanche as shown in the section, Fig. 2.

B   C
(Fig. 2.)   Section through Cape Negro and Negro Island

Devonian   Pre-Cambrian
[granite symbol] Granite   [schist symbol] Schist   [quartzite symbol] Quartzite
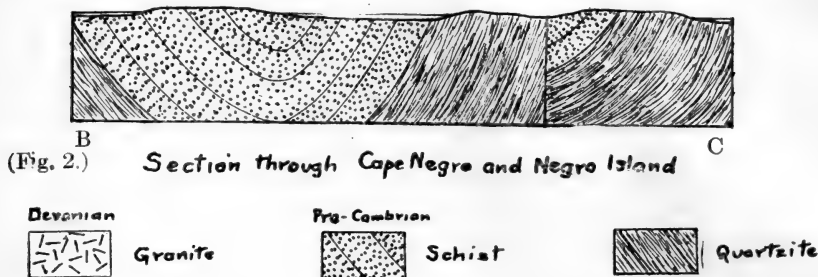
John Island, west of the Blanche peninsula, is underlain by staurolite schists striking N 30° E and dipping 40° S.

At Port Clyde dark mica schist interbedded with micaceous quartzite forms an anticline with its axis striking N 20° E. Near Villagedale, on the western side of the Baccaro Peninsula, highly micaceous quartzite reappears striking N 15° E to N 15° W and dipping at a very high angle eastward. This is probably the same quartzite as at Port Clyde, appearing on the limb of a syncline. At Villagedale the quartzite is highly contorted by the granite which outcrops a short distance to the north. The large amount of muscovite and biotite and the small garnets in the rock were formed by recrystallization at the time of the granitic intrusion. Similar quartzite is reported by Dr. Bailey on the south eastern end of Cape Sable Island, indicating that part of that island consists of granite.

Near Port LaTour quartzite outcrops in several places but does not show any bedding. On the islands to the south, a number of roches moutonnées are found in which staurolite schist is exposed. The staurolites are about an inch in length

PLATE II.

The barren boulder-covered land north of Roseway, laid bare by the destructive fire of August, 1911. The boulders of this ground moraine consist of Shelburne granite, but the region is underlain by staurolite schist. Many square miles in Shelburne County consist of such land which is only good for forests.

PLATE III.

A detailed view of the staurolite schist at Crows Neck, south of Port LaTour. The staurolite prisms are mostly one to two inches long. At the base of the picture may be seen rounded masses of chlorite. The extent of post-glacial weathering is shown by the relief of the staurolites.

and quite numerous. The peculiarity of the rock hereabouts is the abundance of large patches of chlorite three to four inches in diameter, with rounded or quadrangular outlines. They have probably been formed as a replacement of hornblende, but no trace of the original mineral was discovered. A thin section of the rock from one of the islands shows a fine groundmass of quartz and sericite in which are large metacrysts of staurolite which enclose numerous quartz grains, large crystals of biotite which enclose small grains of quartz and titanite, metacrysts of garnet, some pennine and small amounts of iron ore and apatite. The strike of the rocks is due E-W with a dip of 20° S. The same staurolite schist continues around Baccaro Point, but quartzite appears on the Barrington Bay shore a mile west of Port LaTour.

IGNEOUS ROCKS

Micaceous granitic rocks occupy the central part of the peninsula of Nova Scotia, smaller masses appearing in numerous places from Halifax northeastward to Cape Canso, and also south of the main area. Two of the latter enter the area under consideration, at Shelburne and at Barrington. These batholiths consist respectively of biotite-muscovite granite and of quartz (biotite) diorite, with some pink aplitic granite in the immediate vicinity of Barrington.

The age of these granites is Middle Devonian; they cut the fossiliferous Lower Devonian slates of Clementsvale and of Torbrook-Nicteau, and the arkose derived from the weathering of these granites at Horton Bluff is found abundantly in the Horton Series which is of basal Mississippian age (Pocono, according to David White). The granites were intruded at the time of the Middle Devonian revolution which folded the Canadian Appalachian geosyncline and the region now embraced in the Maritime Provinces. The folding was not completed at the time of the intrusion of the granite because the latter shows the effect of a moderate amount of shearing.

Concerning the character of the granite in the neighborhood of the gold mines in Lunenburg and Halifax counties, where it has been studied the most, Mr. E R. Faribault writes*:

"The composition and texture of the granite varies much with the locality and mode of occurrence. The rock consists for the most part of a light grey or reddish grey coarse porphyritic biotite granite, generally studded with large phenocrysts of white or pink-white feldspar. In the west, a light pearl-grey or pinkish-white fine-grained muscovite granite occupies small areas penetrating the biotite granite as well as the sediments. With the muscovite granite are associated dikes of coarse pegmatite often passing to quartz, and bearing a large variety of minerals."

The Shelburne granite was observed in outcrops three miles south of the town, just south of the first outcrops of schist on the shore. The granite is porphyritic and includes fragments of schist. The schist is micaceous, a feature common to the sediments whenever near a granite contact, and it is cut by aplite veins one to three inches wide. Frequent outcrops of granite are found in railroad cuts southwest of Shelburne and at a quarry near Hart Point. The granite in the railroad cuts is cut by pegmatite dikes, the largest of which is three feet wide. Numerous pegmatite dikes are also found in boulders in this vicinity. The pegmatite consists of large pink orthoclase crystals (4 inches long, 3 inches wide and thick), masses of quartz in smaller quantities than the feldspar, plates of muscovite one inch in diameter, less abundant biotite crystals, a white feldspar showing albite twinning (probably oligoclase), garnets one-quarter of an inch in diameter, and occasional masses of tourmaline. One crystal of beryl, one and one half inches in width and length, was found.

The Shelburne granite is a light grey, fine-grained, micaceous granite with biotite generally predominating over

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* International Geological Congress, Guide Book, 1, pt. 1, p. 168, 1913.

muscovite. When the mica, especially the muscovite, becomes more abundant, the rock has a slightly yellow tinge. The feldspar and quartz both occur in small grains, the former being white, and hence less conspicuous than the flakes of mica. Under the microscope the rock is seen to consist principally of xenomorphic crystals of feldspar and quartz, the latter showing undulating extinctions due to shearing, biotite in very numerous shreds and flakes between the other grains, accessory muscovite in occasional shreds both inside and outside the feldspars, and a few apatite crystals inside feldspars and muscovite crystals. The feldspar consists largely of oligoclase, with some albite-oligoclase ($Ab_9 An_1$) and albite-microcline microperthite. The results of a Rosiwal measurement of the rock will be found below. One slide shows a number of mermycitic intergrowths of the quartz and oligoclase feldspar. Some of the latter show zonal growths and occasionally undulating extinctions. The muscovite appears to be largely secondary, probably being developed by pneumatolytic action. In some cases it shows the same amount of shearing as the remainder of the rock and is therefore thought to be primary.

The Barrington batholithic area contains two kinds of rock, a pink aplitic granite at Barrington, and a biotite quartz diorite elsewhere. The relation of these two rocks is not known, only two exposures of the former being found, and a few of the latter. It is to be inferred from the relation of similar rocks elsewhere, as shown by the quotation given above, that the aplitic granite is the younger, yet probably intruded during the same diastrophic period.

The aplitic granite outcrops an eighth of a mile northeast of the Barrington railroad station. The same granite cuts micaceous quartzite at the crossing of the railroad and the road north from Villagedale. Between this outcrop and Villagedale, at Solid Rock and also for a mile south of Solid Rock, micaceous quartzite is cut by numerous stringers of aplite,

belonging to this granitic intrusion. The quartzite is highly contorted and the mica is a phase of the exomorphic metamorphism.

In a hand specimen the rock is seen to be a pinkish, very fine-grained granite, minutely porphyritic. The feldspar shows albite twinning in the larger crystals. Mica is distributed unevenly through the rock in small quantities, both muscovite and biotite being present. The quartz lies between the feldspar and is less conspicuous. In thin section the rock is seen to consist of feldspar in hypidiomorphic crystals, a much smaller amount of quartz, rather abundant secondary muscovite, an occasional biotite flake, and some chlorite and titanite. The feldspar is largely a microcline microperthite with smaller amounts of oligoclase. The centers of many of the feldspar crystals are filled with specks of sericite.

The quartz diorite appears to form the remainder of the igneous rock of the area. Outcrops were noted a half mile west of Barrington, at Barrington Passage and to the southward in railroad cuts, and at Shag Harbor. It is a light grey, fine grained rock and shows the effect of shearing, the biotite flakes being orientated into parallelism. Albite-twinned white feldspar and colorless quartz in small amount may be seen in the rock. The grain of the rock is fine, but a few feldspar phenocrysts one-half inch in length may be seen. Under the microscope the constituents are found to be hypidiomorphic crystals of feldspar, a small amount of brecciated quartz showing undulating extinctions, large plates of biotite often clustered in the more brecciated places, accessory titanite in small granular aggregations, quite numerous long rods of apatite occurring in association with the biotite, and a very small amount of iron ore, zircon and muscovite. The feldspar is principally oligoclase twinned after the albite and pericline laws, with smaller amounts of microcline microperthite and albite-oligoclase. The more acid feldspars do not appear in

sufficient abundance for the rock to be called a quartz mon-zonite.

Rosiwal measurements of the mineral composition by weight of this quartz diorite and of the Shelburne granite are given for comparison:

Barrington quartz diorite		Shelburne granite	
Oligoclase	54.6	Oligoclase	35.2
Albite-oligoclase	.8	Microperthite	3.1
Quartz	21.2	Albite-oligoclase	17.1
Biotite	23.1	Quartz	33.6
Muscovite	.3	Biotite	7.8
	———	Muscovite	3.1
	100.0	Apatite	.1
			———
			100.0

From these measurements the chemical composition has been calculated:

	Barrington quartz diorite	Shelburne granite
$Si O_2$	63.6	72.3
$Al_2 O_3$	16.8	15.2
$Fe_2 O_3$	2.0	.6
FeO	3.0	1.1
MgO	3.1	1.0
CaO	3.3	2.5
$Na_2 O$	4.8	5.0
$K_2 O$	2.1	1.5
Rest	1.3	.8
	———	———
	100.0	100.0

The most important characteristic of the granite and quartz diorite is the high soda content. The two rocks are petrographically related, the feldspar being of the same composition and differing only in amounts as do the other constituents.

DYNAMIC GEOLOGY.

The first question which arises in considering the dynamical history of the region is the date of the folding and faulting of the pre-Cambrian sediments. The folding probably took place in pre-Cambrian times, and the faulting in the Devonian diastrophism. The goldbearing series is unconformably over-lain by Silurian and by Lower Devonian sediments.

The effect of the folding of the Goldbearing series, was to produce a series of closely folded anticlines and synclines. The axes of these folds are parallel. In Queens County northeast of Shelburne County, the axes trend in a N 45° E to a N 55° E direction, and this direction is characteristic of axes of folds in Lunenburg and Halifax counties to the east. In Yar-mouth County, on the west of Shelburne, the trend is N 20°-30° E. In Shelburne County, however, the main axes, ac-cording to Dr. Bailey's map, turn toward the Atlantic Ocean in a N 15°-20° E direction. The major axes of the batholiths as shown on the same map, are about N 5° E. In the coastal region considered in this paper, the principal folds are ob-scured by block faulting*, but the axial direction is N 20° E. It is therefore evident that these axes of mountain-building turn from a S 45° W direction to one of S 20° W, which is toward the Atlantic Ocean and not parallel to the coast line of North America. In "La Face de la Terre" Vol. 1 (fig. 103) Suess and de Margerie plot the tectonic axes of eastern North America, and show the axis of southwestern Nova Scotia turn-ing from a S 65° W direction to one of S 15° E. In view of the above data, it is clear that a turn as great as 80° does not exist. The existing turn is comparable to that of the axis of the Canadian Appalachians into the axis of the Taconic Mount-ains.

The Goldbearing series throughout Nova Scotia has under-gone extensive metamorphism which appears to be entirely

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*The faulting is dated, from evidence found elsewhere, as later than the batholithic intrusion, and therefore does not concern the question at hand.

dynamic and contact metamorphism. The former, as shown in Lunenburg and Halifax counties, produced thick-bedded compact quartzite, usually showing minute flakes of mica, and siliceous slates, usually of a grey-green color and very fine grain with no metacrysts. The metamorphism of these beds was not quite completed when the granitic intrusions of Middle Devonian age took place, for the igneous rock is everywhere more or less sheared. The contact metamorphism near the granite has produced recrystallized schist and quartzite, and farther away has caused the formation of metacrystals of staurolite, andalusite, biotite, hornblende, garnet and sillimanite.

In the southern portion of Shelburne County, the contact metamorphism has been so extensive as to be almost regional. On Negro Island, which is 10 miles fron the nearest granite outcrop, the staurolites still persist in the schist although the quartzite is free from metacrysts. The characteristic features of the metamorphism are the development of either staurolite or mica or both in the schist everywhere, the recrystallization of the quartzite near the granite with the development of the muscovite in large quantities and some biotite, and the lack of alteration of the quartzite elsewhere, except near Sand Point where within three miles of the granite some metacrysts appear.

The date of the block faulting, which is shown on the map, is probably late Carboniferous. This diastrophic period did not develop intense folding in the Maritime Provinces, but it was accompanied by faulting. In Kings County the faulting is later than the intrusion of igneous rocks of Devonian age. The details concerning these faults have been sufficiently discussed above. Faults are characteristic of the Goldbearing series throughout its extent, but this block faulting is uncommon in the districts near the gold mines.

ECONOMIC GEOLOGY.

The most valuable economic resource of the district is granite. West of Shelburne near Hart Point and not over a mile from the Halifax and South-Western Railroad is a granite quarry in bed rock. This quarry has been worked for a number of years, the activity fluctuating with the demand for the product. The granite was loaded on boats within a short distance of the quarry. Also, an extensive quarry business has been carried on in granite boulders here as well as in other parts of the County. At present, granite is being quarried from boulders near the railroad track and transported by rail. The granite appears to split easily and should be very good for building purposes

Ochre is reported at Upper Port LaTour. It occurs on the north side of a hill west of the town. Ochre has also been found a mile and a half south of this town, at the bottom of a well hole 10 feet deep. Neither occurrence was investigated.

Although quartz veins occur in this vicinity, no gold mines have been opened. The saddle reefs of quartz, from which most of the gold is secured in the Halifax district, could not have been formed in a region so highly metamorphosed as the one here considered.

SUMMARY.

The pre-Cambrian Meguma or Goldbearing series was folded into a number of parallel anticlines and synclines and dynamically metamorphosed in the Middle Devonian diastrophism. Granites, quartz diorites and aplitic granites were intruded at this time, being caught in the last of the mountain building movements. These intrusions produced extensive contact metamorphism, staurolite schist being developed ten miles from the nearest granite outcrop. Later, and probably in late Carboniferous time, extensive block faulting took place.

PLATE IV.

A view of Cape Sable Island showing the dissected and downwarped Cretaceous peneplain. This large island is completely covered by glacial deposits, only one bed rock outcrop being found by Dr. L. W. Bailey. A large fire was burning on the island at the time this picture was taken.

The trend of the axes of mountain building, which have determined the outlines of Nova Scotia, turns in Shelburne County from about S 45° W to S 20° W. The axes therefore point away from the land as they dip under the sea, but not at such an angle as given by Suess and de Margerie.

Probably since the end of the pre-Cambrian at least part of the rocks of the Goldbearing series has been exposed to denudation. At the time the ice sheet advanced over the region in the Pleistocene, long valleys had been formed in the Cretaceous peneplain. The land was depressed at about this time to its present level, drowning the ends of the valleys and making the fiords and islands which now characterize the coast line. The action of the ice was to bevel off the rock, but also to leave a thick veneer of sandy ground moraine and boulders over the entire country. Many islands and peninsulas consist, above the present sea level, almost wholly of glacial deposits. Along the depressed shore line the sea is re-working these deposits with the formation of abundant beaches and bars, and in only a few places has the sea cut through the thick veneer and attacked the bed rock.

Coloured Thinking and Allied Conditions.—By D. Fraser Harris, M. D., D. Sc., F. R. S. E., Professor of Physiology in Dalhousie University, Halifax, N. S.

There are certain persons in whom sounds are invariably and inevitably associated with colours. Whether these sounds are those of the human voice or the notes of various musical instruments, they are all heard as coloured. This kind of thing is known as coloured hearing; in French, *audition coloreé;* in German, *farbiges Hören.*

The linking together of any two kinds of sensation is called synæsthesia; of all the possible synæsthesiæ, the linking of colour and sound is the commonest. A larger number of persons than might be supposed are the subjects of coloured hearing. As long ago as 1864, the chromatic associations of one of these coloured hearers were described by Benjamin Lumley([2]). "I know a person," he wrote, "with whom music and colours are so intimately associated that whenever this person listens to a singer, a colour corresponding to his voice becomes visible to his eyes, the greater the volume of the voice the more distinct is the colour." This person heard Mario's voice as violet, Sims Reeves' as gold-brown, Grisi's as primrose, and so on.

But there is also a small number of persons who, whether they hear in colours or not, always *think* in colours. These persons, called coloured thinkers, do not have any sensation of colour when voices or notes are heard, but they invariably associate some kind of colour with such things as the names of the days of the week, the hours of the day, the months of the year, the vowels, the consonants, etc. This faculty is coloured thinking or chromatic conception and has been called psychochromæsthesia. A typical coloured thinker

who will tell you, for instance, that Sunday is yellow, Wednesday brown, Friday black, may not experience any sensation of colour on hearing the organ played or a song sung. Certain persons are indeed coloured hearers as well as coloured thinkers; but we should distinguish the person who has linked sensations, a synæsthete, from the person whose thoughts are coloured, whose mentation is chromatic, who is, in fact, a psychochromæsthete.

The literature of synæsthesia is much more extensive than any one would be inclined to think who had not made it a special study. Nor is the condition described only in technical publications; there is an increasing tendency to recognize it in current fiction. Thus in "Dorian Grey" we have— "her voice was exquisite, but from the point of view of tone it was absolutely false. It was wrong in colour". Musicians, it would appear, are particularly liable to hear in colours— "The aria in A sharp (Schubert) is of so sunny a warmth and of so delicate a green that it seems to me when I hear it that I breathe the scent of young fir-trees". The musical critic of the "Birmingham Daily Post" thus once complained of a lady's singing; "Her voice should have been luscious like purple grapes". Punch has, of course, not failed to notice this tendency in musical criticism. A writer in the "Daily Telegraph" had thus expressed himself — "To a rather dark coloured, deep, mezzo-soprano voice, the singer joins a splendid temperament"; Punch remarked, "We, ourselves, prefer a plum-coloured voice with blue stripes or else something of a tartan timbre".

Monsieur Peillaube([53]), editor of the *Revue Philosphique*, has reported on four persons who have well marked coloured hearing for organ notes, and he calls attention to the numerous cases amongst musicians of definite associations between notes and musical instruments on the one hand, and colours on the other as well as between whole pieces of music and colours. Thus Gounod, endeavouring to express the dif-

ference between the French and Italian languages and giving his preference to the former, used terms relating to colours: "Elle est moins rich de coloris, soit, mais elle est plus variée et plus fins de tintes".

. Theoretically, any two sensations may be linked, so that coloured hearing is only one particular variety of synæsthesia (coupled sensations, secondary or dual sensations, second-ärempfindungen). No doubt the linking of colour with sound is the commonest of these dual sensations which, following Bleuler[31], might be called sound-photisms. When a taste produces light or colours we have a taste-photism; similarly, there are odour-photisms, touch-photisms, tem-perature-photisms, and pain-photisms recorded in the annals of abnormal psychology. A good example of pain-photism occurs in a recent novel, "The Dream Ship"[66]. The whole passage is so appropriate to our subject that it may be quoted in full:—"Bran" (a boy) "decided all his likes and dislikes by colour and smell. His favourite colours were yellow, red, green, and wet-black. The last was very different to (sic) ordinary black which was the colour of toothache. Little rheumatic pains, which he sometimes got in his knees, were grey. The worst pain you could get was a purply-red one which came when you were sad and gave you the stomach ache. He had once solemnly stated that the only colour he hated was yellow-pink, but as he always called yellow pink and pink yellow, no one had been able to solve the riddle of this hated colour." The black colours of toothache and the grey of rheumatism were this boy's pain-photisms. Something of the reverse order is indicated where a dis-agreeable colour is described as producing a pain in the stomach. When Baudelaire said that musk reminded him of scarlet and gold, he had an odour-photism.

When the reverse linking occurs, we have an analogous series as follows,—If light or colour produces a sound, it is

a light- or colour-phonism.   When a taste is coupled with
a sound, we have a taste-phonism and there may exist
odour-, touch-, temperature- or pain-phonisms respectively.
Sometimes the second sensation linked is of a more
vague character, as when screeching sounds produce
disagreeable general sensations very difficult to describe.
They have been called secondary sensations of general
feeling, and they may be akin to those unpleasant
sensations evidently experienced by dogs and other animals
when they hear music.   The late Mr. Grant Allen was
evidently alluding to this kind of thing when he wrote in an
article on "Scales and Colours," that "Chaos was
in dark and gloomy colours, whereas light was treated in
white" in such a work as Hadyn's "Creation."

Bleuler[31] believes that phonisms of high pitch are pro-
duced by bright lights, well defined outlines, small and
pointed forms, whereas phonisms of low pitch are produced
by the opposite conditions.   An interesting point may be
mentioned in connexion with the difference in colour aroused
by spoken words and by whispering.   Dr. Hélène Stelzner[5]
tells us that in her own case full-toned speech appears as a
coloured picture, whereas whispering, with its much less
resonant vowels, appears like a copper-plate engraving,
that is, as non-chromatic.

Quite apart from all these things— synæsthesia—is
coloured thinking or chromatic mentation.   Here it is not
a question of a sensation being present at all, it is that cer-
tain persons who have this power, faculty or disability
cannot visualize any concept without seeing it in "the mind's
eye" as coloured in some way or other.   Indeed, the majority
of the coloured thinkers questioned by the author do not
experience colours when they hear sounds or musical tones,
but they cannot think of anything definitely, the month,
the day, the hour, without its being thought of as red
or yellow or black or white or brown or green or blue.   There

is no approach towards unanimity in the colours thought of in association with any one concept or word; for instance, for Saturday the colours selected at random from records in my possession are white, yellow, steel-grey, white-grey, crimson, brown. The coloured thought may be called a psychochrome, and persons who think in colours psycho-chromæsthetes, the faculty or disposition to think in colours being psychochromæsthesia. Something analogous to this is the case of the blind man alluded to by Locke[1] to whom scarlet was "like the sound of a trumpet."

Apparently the concepts to be most commonly coloured are those for the vowels, the consonants, the months, the days, and the hours of the day. Thus the vowel "a" as in "fame" is mentally coloured in the following five ways in five different persons—red, black, green, white-grey, and white respectively. Or take the vowel "u" as in "usual", we find it psychically coloured as grey-white, yellow, black, brown, blue, and green in six different coloured thinkers. Similarly whole words are associated with colours in the minds of this class of thinkers. One person says he divides all words into two great classes, the dark and the light. Random examples of dark words are man, hill, night, horse, Rome, London, and of light, sea, child, silver, year, day, and Cairo. Or again, another coloured thinker divides up the numerals into those associated with cold colours, grey, black, blue, green; and those with warm, red, yellow, orange, brown, purple, and pink. The odd numbers have the cold colours; the even, the warm. In some cases, as might be expected, the coloured concepts are appropriate or natural as when the word scarlet is scarlet; black, black; and white, white. But an examination of psychochromes shows us that this reasonableness does not necessarily always occur. Thus, the word "apple" is to one coloured thinker a slate grey, which is not the colour of any real apple; and the word "cucumber" to the same person is white; now only the inside of the vegetable itself is white.

Some kind of method, however, may be traced in this chromatic madness, for, according to Bleuler ([31]) high-pitched notes produce the lighter tints of colour, but low-pitched the darker shades. According to this authority, the colours oftenest aroused in the synæsthesia, sound-photism, are dark brown, dark red, yellow, and white, which is not at all the statement of the frequency of occurrence of colours in coloured thinking. From the records of the psychochromes of two brothers, the relative order of frequency of the colours is white or grey, brown, black, yellow, red, green, and blue; violet and indigo not occurring. Dr. Hélène Stelzner([5]) says that green is the colour least commonly thought of. But individual differences are extreme: thus both purple and violet are such favourites with some coloured thinkers that they hardly ever think in terms of any other colours. The present writer([55]) has examined the psychochromes of two men, one woman, and one child, with the result that the relative order of frequency of occurrence comes out as white, brown, black, yellow, green, blue, red, pink, cream, orange, and purple. It is thus clear that the colours thought of are not exclusively the pure or spectral ones, for certain non-spectral colours like brown, pink, cream, white, and black are quite commonly reported. The novelist, Ellen Thornycroft Fowler, in a private communication to the author, wrote—"The colour which I always associate with myself, for no earthly reason that I can discover, is blue. Therefore, "E", my initial letter is blue; April, the month of my birthday is blue, and 9, the date of my birthday, is blue." This is known as "colour individuation", and has been made a special study of by Paul Sokolov([47]) in his paper "L'individuation colorée" read before the fourth international congress of Psychology held at Paris, 1900. Some people, in short, have their favourite colours, and with these they invest their pleasant thoughts, while their unpleasant thoughts they find coloured by the tints they are not fond of.

Apart, however, from whether certain colours are fav-
ourites or not, some few persons have the consciousness of a
colour more or less present with them.   Thus, R. L. Steven-
son had, so he tells us, a feeling of brown which, during his
attacks of fever, was unusually distinct.   It was "a peculiar
shade of brown, something like sealskin".

As might be expected, so acute an observer as Mr. Rudyard
Kipling has not failed to notice coloured thinking.   In
his very curious story "They",(52) he describes the colour
concepts experienced by a blind old lady who opens an
interview by complaining that certain colours—purple and
black—hurt her.   Her visitor asks, "And what are the
colours at the top of whatever you see?"   "I see them so,"
she replies, "white, green, yellow, red, purple; and when people
are very bad, black across the red, as you were just now."
The old lady goes on to say that ever since she was quite a
child some colours hurt her, and some made her happy.
"I only found out afterwards that other people did not see
the colours."   So unfamiliar is coloured thinking to the
ordinary person that a critic wrote (*The Academy and
Literature*, October 8th, 1904) "Such tales as 'They' are
sheer conundrums."   Another writer asked more pertinently,
"Are the colours the blind woman described, the colours
of different thoughts?"

In Mrs. Felkin's novel, *In subjection* (43) (1900), the
heroine, Isabel Seton, is evidently a coloured thinker.   Some
of her colour associations are given on page 149.   The
novelist, in a letter to the writer, was good enough to explain
that these experiences of her heroine are based on those of
an actual prototype, some of whose additional psychochromes
she has kindly mentioned.   Isabel Seton has synæsthesia
also, for the actual sounds of voices call up colours.   Thus,
soprano voices are to her pale blue or green or yellow or
white; contraltos are pink or red or violet; tenors are dif-
ferent shades of brown; while basses are black or dark green
or navy blue.

In the novel *Christopher* by Richard Pryce, ([61]) there is an interesting allusion to a boy who is described as not morbid although he is evidently a synæsthete and a coloured thinker. He talks of playing the sunset on the piano (a colour-phonism), and of smelling moonlight (a light-olfaction). In a novel, *Youth's Encounter*, ([64]) published in the year 1913 we are told that to one of the characters, "Monday was dull red, Tuesday was cream-coloured, Thursday was dingy purple, Friday was a harsh scarlet, but Wednesday was vivid apple-green, or was it a clear, cool blue?"

It is difficult to express the character of these coloured concepts to persons—and they are the majority of people—who never experience this sort of thing at any time. The colours are not present so vividly as to constitute hallucinations. Coloured visualizings never become hallucinatory, possibly because they are of the nature of thoughts, rather than of subjective sensations. Chromatic conception belongs to the physiology not to the pathology of mind. Coloured thinkers are not continually plagued with phantasmagoria. Mental colourings do not obtrude themselves into one's mental life, they are habitual, natural, chromatic tincturings of one's concepts, and have been so long present to consciousness that they have long ago become part of one's mental belongings. They are invariable and definite without being disturbing.

One coloured thinker has thus expressed himself: "When I think at all definitely about the month of January, the name or word appears to me reddish, whereas April is white, May yellow, the vowel 'i' is always black, the letter 'o' white, and 'w' indigo-blue. Only by a determined effort can I think of 'b' as green or blue, for me it always has been and must be black; to imagine August as anything but white seems to me an impossiblity, an altering of the inherent nature of things." There is thus an inherent definiteness, finality, and constancy about each thinker's psycho-

chromes that is very striking. But it is not alone letters and words that are habitually thought of as coloured, certain coloured thinkers always associate a particular colour with their thoughts about a particular person.

The author of "The Corner of Harley Street"[62] remarks (p. 251) "If only we could use colours now to express our deeper attitude on these occasions, as some of your fellow clergy wear stoles at certain seasons, with what pleasant impunity could we write to one another in yellow or purple or red, leaving black for the editor of the *Times* or the plumber whose bill we are disputing."

"Our alphabet is not rich enough for the notation of the cockney dialect", writes Mr. Richard Whiting in *No. 5 John Street*, "I can but indicate his speech system by a stray word which, if there is anything in the theory of the correspondence between sounds and colours, should have the effect of a stain of London mud." This is evidently an allusion to coloured thinking. There is, unfortunately, no theory at all as yet, but there is the fact of chromatic conception. Quite recently (1913) there was in the "British Review" [65] a vivacious article dealing with coloured thinking from the popular standpoint. The literature that contains the most systematic discussion of coloured thinking is that of the decadent poets of France, the symbolists, as they are called. Some account of their psychochromes is given in Lombroso's "Man of Genius"[30]. The eccentric poet, Paul Verlaine, belonged to this school. It evidently includes synæsthetes as well as coloured thinkers for, for them, the organ is black, the harp white, the violin blue, the trumpet red, and the flute yellow. But they think of the vowel "a" as black, "e" as, white, "i" blue, "o" red, and "u" yellow. One of them, Stéphane Mallarmé, has explained in his pamphlet *Traité du Verbe* how these things have come to be.

The following verses—for I hesitate to call them poetry—seem to be an attempt to express the associations of emotions symbolized by the mental colourings of the vowels:

VOYELLES

A noir, E blanc, I rouge, U vert, O bleu, voyelles,
Je dirai quelque jour vos naissances latentes;
A, noir corset velu des mouches éclatantes
Qui bombillent autour des puanteurs cruelles.

Golfes d'ombre, E, candeur des vapeurs et des tentes,
Lances des guerrièrs fiers, rois blancs, frissons d'ombelles,
I, pourpres, sang craché, rire des lèvres belles
Dans la colére ou les ivresses pénitentes.

U, cycles vibrement divins des mers virides,
Paix des pâtis semès d'animaux, paix des rides
Que l'alchemie imprime aux grands fronts studieux.

O, suprème clairon plein de strideurs étranges,
Silence traversée des Mondes et des Anges,
O, l'omega, rayon violet des ses yeux.

J. A. Rimbaud.

We are now perhaps in a position to make some inquiry into the characteristic features of coloured thinking. The first point that strikes one is the very early age at which these associations are fixed. This was a feature recognized by Galton in his classic examination of the subject in 1883[10] The present author's observations fully confirm this point; he has in his possession many letters from coloured thinkers in which the details of their psychochromes differ in the widest possible manner, but all agree in that they testify to the very early age at which the associations were formed. After the publication of the writer's article in the "Scotsman," December 29th, 1908,[59] he received a number of letters spontaneously sent, all emphasising this feature in such

phrases as, "ever since I can remember", "ever since child-
hood I have always had it", "I do not remember the time
when I had not", etc.   A writer in "Nature" in 1891,([29])
reports on the psychochromes of his daughter when seven
years old, at which age she had specifically different colours
for the days of the week, namely: blue, pink, brown or grey,
brown or grey, white, white, and black.   The months of the
year were coloured in the following way by a girl of ten who
had so thought of them ever since she could remember:
brown, olive-green, "art" blue, green-yellow, pink, pale
green, pale mauve, orange, orange-brown, grey, grey out-
lined in black and finally red.

A boy ten years old is reported in the article on Colour
Hearing in the "British Review",([65]) to have "noticed that
the number eight invariably provoked in him the sensation
of apricot-yellow, and the number fifteen that of peacock
blue".   There seems not the slightest doubt that these
colour associations are amongst the earliest that are formed
in the child mind of the coloured thinker.

The second characteristic of coloured thinking is the
unchangeableness of the colour thought of.   Middle-aged
people will tell you that there has been no alteration in the
colours or even in the tints and shades of colour which, for
many years, they have associated with their various concepts.
Galton remarked on this in his original monograph: "They
are very little altered," he said, " by the accidents of educa-
tion."   Galton's phrase was they result from "Nature not
nurture".   Just as their origination is not due to the in-
fluence of the environment, so the environment exercises no
modifying influence on them even during a long life.

The third characteristic of psychochromes is the extreme
definiteness in the minds of their possessors.   Contrary to
what might reasonably be expected, the precise colours
attached to concepts are by no means vague or incapable
of accurate verbal description.   A coloured thinker is most

fastidious in the choice of terms to give adequate expression to his chromatic imagery. One of these is not content, for instance, with speaking of September as grey, he must call it steel-grey; another speaks of a dull white, of a silvery white, of "the colour of white watered silk," and so on. One child speaks of March as "art blue," whatever that is; another of 6 p. m. as *pinkish*. The degree of chromatic precision which can be given by coloured thinkers to their visualizing is as extraordinary as any of the other extraordinary things connected with this curious subject.

The fourth characteristic is the complete non-agreement between the various colours attached to the same concept in the minds of coloured thinkers. Thus, nine different persons think of Tuesday in terms of the following colours: brown, purple, dark purple, brown, blue, white, black, pink, and blue. Again, September is thought of as pale yellow, steel-grey, and orange by three different coloured thinkers respectively. Once more, the vowel "i" is thought of as black, red-violet, yellow, white, and red respectively by five persons gifted with chromatic mentation. Unanimity seems hopeless, agreement quite impossible; the colours are essentially individualistic.

The fifth characteristic of psychochromes is their unaccountableness. No coloured thinker seems to be able to say how he came by his associations; "I cannot account for them in any way" is the invariable remark one finds in letters from persons describing their coloured thoughts.

The sixth characteristic is the hereditary or at least inborn nature of the condition. Galton's phrase was "very hereditary". The extremely early age at which coloured thinking reveals itself would of itself indicate that the tendency was either hereditary or congenital. The details of a case of heredity from father to son have been reported for coloured hearing by Lauret and Duchassoy; a case of coloured thinking reported by the present writer was one

of heredity also from father to son. But these related
coloured hearers did not see the same colours for the same
sound, nor did the two coloured thinkers think in the same
colours. From the writer's inquiries, coloured thinking is
certainly congenital even when it cannot be proved to be
hereditary. This point will come up again in connexion
with the origin of the condition, but we may at present note
that those who have studied the subject are unanimous in
denying that at any rate coloured thinking is due to environ-
mental influences.

It may be now asked what manner of people are they
who are coloured hearers or coloured thinkers or both. The
late Mr. Galton told us that they are rather above than
below the average intelligence. The writer's observation
would, in the main, confirm this; they are at least invariably
well educated persons who confess to being coloured thinkers.
In his book, Mr. Galton gave a few names of distinguished
persons of his acquaintance, and his list might be brought
up to date by the addition of some names quite as distinguished.
But all persons who have coloured hearing or coloured think-
ing are not necessarily distinguished—a large number, as
we have seen, are yet children—but they are all probably
more or less sensitive. Possibly they are more given to
introspection than is the ordinary person. At any rate,
what is quite certain is that both synæsthetes and psycho-
chromæsthetes belong to the group of strong visuals or
"seers" as Galton called them. Seers are persons who visual-
ize or exteriorize their concepts either as uncoloured forms
or as coloured in some way or other. The uncoloured thought-
forms are very curious, some of which Galton gave as examples
in the appendix to his work. One distinguished neurologist
always sees the numerals 1 to 100 in the form of a ladder
sloping upwards from left to right into the sky. As this
concept is not coloured, it cannot be called a psychochrome,
but it might be called a psychogram. A psychogram is,

then, the uncoloured thought-form of a concept, and people who have psychograms must be strong visualizers.

The school of symbolist poets in France to which Ghil, Malarmé, Rimbaud, and Verlaine belong, appears to lay a great deal of stress on the so-called meaning of colours. The school evidently includes both coloured hearers and coloured thinkers; but, whereas, the majority of coloured thinkers derive no particular meaning from their psychochromes, the symbolists attach considerable significance to the colours which happen to be associated with their thoughts. The different vowels, for instance, mean to them or represent for them particular emotions or states of mind not in virtue of the sound of the vowel but entirely through the related colour. The particular emotion symbolized by any given colour seems to the ordinary person rather arbitrary if we judge by the details in Rimbaud's poem; but we are aware that there has always been a tendency to represent emotional states in terms of the language of colour. Homer spoke of "black pains"; we constantly speak of a black outlook, a black lie, a white lie, a black record, a grey life, a colourless life, and so on. There is, in fact, growing up in England a school of musicians who hold that it should be possible and pleasurable to represent music chromatically. Whether the general public will ever enjoy silent music seems very doubtful, but it is notorious that most people derive a great deal of pleasure from the display of coloured lights, illuminated vapours, coloured steam, "fairy fountains", Bengal lights, a house on fire, and similar exhibitions in the open air. People undoubtedly do like to see great surfaces or masses vividly coloured as in the rainbow, the sunrise or sunset, the afterglow on snowy mountains, the streamers of the northern lights, and so forth. But whether they would care to have audible music suppressed and to have offered them a succession of coloured surfaces or patches of colour even following one another in the se-

quence or rythm required by music, is open to serious question. Such, however, is the intention of Mr. A. W. Rimington, as explained in his book, "Colour in Music",([63]) in which there is much that is true and interesting. "It is undeniable," he writes, "that as a nation our colour sense is practically dormant . . . Compare our colour sense with that possessed by the Japanese, the Indians, or even the Bulgarians and Spaniards. . . To my mind, a wide-spread, refined colour-sense is more important than a musical one." Long before Mr. Rimington's work was published, there appeared a little book privately printed at Leith in Scotland called "Chromography or tone-colour music"([23]). The author assigned a colour to each of the notes of the scale thus— do = red, re = orange; mi = yellow; fa = green; sol = blue; la = violet-purple; ti = red-purple.

Many persons have synæsthesia in connexion with musical tones (sound-photisms); two cases reported by Albertoni([24]) associated blue with the sound of Do (C); yellow with Mi (E); and red with Sol (G). But it was discovered that they were colour-blind for red (Daltonism). Now, whereas, they could recognize and name the other notes, they could not name G, a disability which Albertoni thinks was related to the Daltonism; he has accordingly called it Auditory Daltonism ((Daltonismus auditivus), a psychical deafness depending on the red-blindness since the note to which they were psychically deaf was the one which called up mentally the particular colour, red, to which they were actually blind.

It might be now asked whether we have any explanation of the causes or causal conditions of coloured thinking; why may thoughts be coloured at all; and why should particular thoughts come to be associated with particular colours? Why should only a few persons, about 12 per cent. in fact, be found to be coloured thinkers? The answers, if answers they can be called, are disappointing in the extreme,

for we have no satisfactory explanations of any of these matters. The very arbitrariness of the associations defies theoretical analysis.

If it is the function of science merely to describe, then our work is done; but in a subject such as this, to make no attempt to account for the abstruse phenomena observed would be a distinctly feeble conclusion of our studies. It has been suggested that the case of coloured thinking is no more recondite than the influence of some picture-book or paint-box, which in early life determined for us ever afterwards the colours of certain concepts. Now, though many people do regard their coloured thinking as a childish survival, the picture-books will account for very few of the best established psychochromes. In some few cases, environmental influences do seem to have been casual. Thus, in one case known to the writer, the colour of February as white was accounted for by the influence of the surroundings. The earliest February remembered was snowy, and through the whiteness of the snow the concept of February came to be and ever afterwards remained white. But it is clear that if environmental influences are operative in anything like a large number of cases, the colours for such concepts as the months of the year ought to be far more uniform than they are. No common origin of external source can make one person think of August as white, another as brown and yet another as crimson. If August is white to one person because it is the month of white harvest, then it ought to be white to all persons capable of receiving any impressions as to the colours of harvest. But to the vast majority of people it is perfectly absurd to talk of August having any colour at all; and to the few who think it coloured, it has not by any means the same colour; all seems confusion.

Monsieur Peillaube([54]) has made a suggestion of a different kind as likely to explain some of these colour associations.

Monsieur Peillaube became acquainted with a Monsieur Ch—— who had audition colorée as well as colored thinking. Monsieur Ch—— had an excellent memory and was able to submit his conceptions to searching introspection with the result that he seems to have discovered what may be called the missing link in the associational chain of mental chromatic events. To this coloured thinker the lower notes of the organ were of a violet colour. This seems to have been brought about in the following way: low notes of any kind were sweet and deep (douces et profondes), the colour violet is sweet and deep, therefore it came to pass that the low notes were associated with violet. Similarly, to Monsieur Ch—— the vowel sound of "i" was suggestive of something "vive et gaie," the colour green had always been associated with liveliness and gaiety, therefore he thought the vowel "i" was green. These conclusions were reached only after considerable introspection, for it must be understood that the link between the low notes and the colour violet was by no means an explicit or definite presentation in this person's mind, at the time that Monsieur Peillaube suggested the enquiry. Peillaube's theory, then, is, that these apparently arbitrary and instantaneous linkings of sounds (x) to colours (y) or of thoughts to colours, are really, after all, cases of association of two terms through the intermediation of a third factor an emotional link (l) now subconscious but revivable. The sequence was x-l-y, but in course of time the "l" had dropped out of consciousness leaving the "x" and the "y" apparently indissolubly joined together.

Finally it may be asked, would the capability of coloured thinking cause its possessor to be classed as mentally abnormal. The answer is in the negative. Coloured thinkers may not conform to the usual or most commonly met with mental type, but they deviate from that type only in the same way that geniuses deviate from it. Inasmuch as they

deviate from the normal, coloured thinkers are, of course, abnormal, but there is nothing in them allied to instability of mental balance.   Some coloured thinkers may, no doubt, belong to families in which some degree of mental instability is present, or, on the other hand, some relatives of coloured thinkers may possess a high degree of artistic or musical ability, of scientific or philosophical insight, that quality in fact, of genius so exceedingly difficult to define.   Genius is something notoriously not conferred by training or education, if not inborn it cannot be acquired; exactly the same may be said of coloured thinking.   Our studies have at least shown us this, that it is not in the ordinary type of mental constitution but in the recesses of the slightly supernormal that this recondite problem of psychology presents itself for analysis and explanation.

APPENDIX

Being the psychochromes in an actual case.

a.—blue-white (like a dead tadpole).

b.—dark brown-red.

c.—brighter red.

d.—pea-green.

e.—fawn-yellow.

f.—a yellow, brighter than e.

g.—dark brown, nearly black.

h.—black.

i.—chocolate brown.

j.—a dull red (not the same shade as the other reds).

k.—bright brick-red.

l.—black.

m.—bright yellow.

n.—dark brown (nearly black).

o.—white.

p.—white with just a tinge of blue.

q.—pale blue-green.

r.—black (nearer to h than to l).

s.—white.
t.—mustard colour (ugly).
u.—brown-yellow.
v.—olive green.
w.—red (like c).
x.—green.
y.—an ugly yellow.
z.—very bright scarlet.

Sunday.—red.
Monday.—pea-green.
Tuesday.—fawn yellow.
Wednesday.—black.
Thursday.—fawn (not as bright as Tuesday).
Friday.—green (a very ugly bile colour).
Saturday.—white.

January.—dull red.
February.—fawn.
March.—a green mustard colour.
April.—blue white.
May.—sunshine colour
June.—dull red.
July.—a slightly darker red.
August.—olive green (more yellow than n).
September.—white.
October.—green.
November.—black brown.
December.—a blue shot with green.
Christmas.—white.
Whitsun.—nearly a rose pink.
Easter.—black with something white in the middle.

One.—black.
Two.—blue-white.
Three.—fawn.

Four.—dark red.
Five.—white.
Six.—bright yellow.
Seven.—black.
Eight.—white.
Nine.—green.
Ten.—mustard-green.
Eleven.—brown-yellow-green.
Twelve.—pale brown.

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ANALYSES OF NOVA SCOTIAN SOILS.—BY PROF. L. C. HARLOW,
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"The soil is so complex in its relation to crops that it
has been and still is one of Nature's greatest puzzles." What
intricate actions, physical and chemical, are those which take
place when the rain descends upon, or the salt tide water
spreads over the marsh lands of our Province! Pages are
written upon the action between two substances in a test
tube; it is only natural then that much is afforded for investi-
gation in one of Nature's great test tubes, the Bay of Fundy,
where the fine residues carried by streams from the various
geological formations are mechanically stirred by the ceaseless
tide.

An analysis of the ebb tide water at the mouth of the
Shubenacadie shows .622 grams of silt suspended in
every 1000cc of water. Now this silt is the result of the
breaking down, the weathering and transportation of the
rocks of the Province. Of what is it composed mineralogic-
ally and chemically? A number of investigators as Delagé,
Bonsteel and Ries, who have labored to determine the minerals
in the soil have come to the conclusion that it has all
the minerals unaltered which are present in the rocks. The
commonest are quartz, limonite, hematite, kaolin, feldspar,
micas, apatite, hornblendes, pyroxenes, chlorite, tourmaline,
rutile, calcite, dolomite, selenite, zeolites.

Again the rocks as sandstone, shales, limestones, of one
group, have the same mineral constituents as the granites,
gneisses and schists of another group; but differ first, in the
varying proportion of these minerals, and secondly in that
the first group are water formed, the second heat formed.

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Hence, a soil, whether artifically made by powdering a rock, or taken from a lately deposited marsh area, from a leached hillside or from a field worn out by cropping, will give the essential elements as shown by the analysis of the following:

	A. New tide deposit from Gaspereau River	B. A "worn out" hillside field from Upper Stewiacke, Col. Co.
Insoluble in acid of 1.11 sp. gr.	83.66	80.02
Potash	.72	.42
Soda (Na_2O)	.82	.09
Lime	.9	.55
Magnesia	1.39	.63
Sulphuric acid	.19	.11
Ferric oxide	{ 7.7	3.25
Alumina		5.68
Phosphoric acid	.1	.12
Volatile at red heat	3.57	8.51
Water at 100°	1.1	1.28
Nitrogen	.06	1.8

Further analysis of the same ebb tide water shows in 1000cc 29.95gm. of dissolved solid made up as follows:—

Sodium chloride	24.24
Potassium chloride	.38
Magnesium chloride	2.47
Magnesium bromide	.036
Magnesium sulphate	1.63
Calcium sulphate	1.18

In addition to these, Ditmar gives about 30 other elements which are easily proven in salt water. That rock residue may become available to plants has been proven by Wöhler, who, in a classical experiment, found the zeolite apophyllite to be sufficiently physically soluble in pure water to be recrystallized from it. F. W. Clarke found muscovite, orthoclase, albite, and other micas, feldspars and zeolites to be soluble in pure water.

Again, Lemberg found that leucite, $KAlSi_2O_6$ in NaCs 10% solution gave $NaAlSi_2O_6$ and KCl; also that feldspar with ordinary soluble salts gave similar exchange of basic elements. These are the changes which must be taking place in our Bay of Fundy waters, and of which Cameron of the U. S. Bureau of Soils says "It is to be regretted that there are not more precise data available as to the stability of the various rock forming mineral species in contact with solutions of the more common and readily soluble salts at ordinary temperatures since such data would be of great value for geological, mineralogical and soil studies."

If the tide water with its dissolved matter acting on the newly brought down rock debris presents a wide range of possible new substances, how much more complex will be the action in a field, marsh or upland where we have organic matter, more or less decomposed; soil atmosphere, living plant organisms as bacteria, molds, ferments; animal forms as protozoa, in addition to the rock residues bathed in the soil moisture which is a solution of products yielded by many components and in equilibrium or nearly so with the solids or gases with which it is in contact.

Scientific Agriculture is the handling of this heterogeneous mixture so as to give, with a minimum of labor, the greatest crop return, and yet be able to pass it over to the next generation, not in an exhausted condition, but permanently improved. It is based on knowledge which is far from complete. Our marsh soils in some places are "run out," giving one half ton of hay per acre. Why is this? We usually say that the available plant food is used up; on the other hand the Bureau of Soils at Washington has, within the last ten years, advanced the Toxin theory which is, that plants in exhausted soils are like human beings in a room, the air of which is polluted by excreted substances, disagreeable and sickening; that the growing plant excretes poisons which, if allowed to accumulate in the soil, kill the plant;

that fertilizers by chemical action destroy these poisons, rendering the soil healthful for growing plants.

Some of these toxins, as picoline carboxylic acid, dihydroxystearic acid and agroceric acid, have been isolated from the soil and their deleterious effects shown on seedlings. These two views have led to a long discussion between the soil men at Washington and another group represented by Hall, of England, and Hopkins, of Illinois. One writer says "The practice of Agriculture has suffered and is suffering today from an insufficient accumulation of facts and data and from an overproduction of theories and conclusions".

It is the purpose of this work to provide some data regarding the *ultimate* composition of the rock debris found in the soils of this Province. To this end 125 samples of soil have been collected, 86 of which have been studied with particular emphasis on the chemical analyses and the relationship of the soil to the surrounding rock, both native and drift. This work has been my pastime during vacation seasons since 1908.

Samples were taken as follows:—

24 Marsh soils from various points between Kingsport and Windsor, along the Cobequid Bay and from the Amherst areas.

25 at various places along a line extending across the county from Tatamagouche to Middle Musquodoboit.

12 from the central part of Lunenburg county.

 8 from the Annapolis valley.

10 from the Wentworth valley.

 2 from the Government farm, Truro.

 2 near Antigonish town.

 1 from Guysboro county.

 1 from Digby county.

 1 from Clifton, Colchester county.

This article will present results of the analyses with tentative deductions therefrom. It is expected that this work will be continued so as to include soils from all parts of the Province and special study of certain problems which at present can only be suggested.

While *good* soils differ in the amounts of the essential elements, yet the following standard from Professor Snyder, Minnesota Exp. Station might be taken for comparison:—

Potash soluble in acid	Phospho-ric acid	Lime	Nitrogen
Good soil......... .3-.6%	.15% if neutral or alka-line.	.3 to .5% if partly limestone	.2%
Poor soil .... ·1%	.05%		.07%

The following table gives the composition of typical soils from various geological areas of the Province.

TABLE I.

Constituent		Ign.	Sil.	Permian.			Carboniferous					Triassic		Cambrian	
	A	5	6	1	2	3	4	5a	7	8	9	10	11	13	12
Insoluble	79.95	76.14	76.48	85.92	87.44	86.31	89.00	82.78	72.93	78.04	87.18	81.64	81.45	76.73	73.78
Potash	.29	.12	.36	.15	.11	.12	.13	.3	.5	.39	.26	.31	.41	.15	.3
Soda	.25	.03	.06	.05	.09	.11	.08	.05	.04	.1	.4	.06	.01	.16	.3
Lime	2.16	.38	.3	.3	.3	.29	.4	.17	.5	.27	.25	.3	.2	.3	.35
Magnesia	.55	.23	.42	.41	.72	.29	.52	.92	.49	.23	.28	.7	.83	.74	.38
Sulphuric acid	.03	.18	.05	.08	.07	.07	.05	.11	.09	.08	.14	.07	.04	.08	
Iron oxide	2.68	3.15	3.28	2.65	2.80	3.10	3.40	3.63	3.05	3.45	2.74	3.40	2.90	9.1	2.5
Alumina	5.20	3.74	4.14	2.72	2.72	2.80	2.75	3.89	5.88	5.73	2.22	4.33	3.28		3.75
Phos. acid	.23	.11	.08	.08	.09	.15	.05	.18	.29	.19	.09	.22	.12	.002	.27
Volatile or organic	7.00	12.36	11.88	7.26	4.65	5.01	2.88	7.61	11.66	9.58	5.35	10.28	6.22	11.12	10.85
Moisture		3.49	2.76	1.17	1.13	1.51	.76	.94	4.46	2.06	1.2		3.98	2.37	6.65
Nitrogen	.29	.34	.18	.15	.08	.1	.02	.18	.24	.23	.14	.17	.1	.21	.34

EXPLANATION OF TABLE I.

A.—Average of 200 United States fertile surface soils. Snyder, Minnesota Exp. station.

No. 5—From the head of Wentworth valley, Cumberland county, would be made up of debris from the igneous rock of the Cobequids; organic matter is due to the field being used as pasture for a long time.

No. 5—The Silurian rock area in Nova Scotia is small; this sample from near Wentworth Station is a mixture of decayed igneous rock, Silurian sandstone and Drift.

Nos. 1 and 2—are typical of the large Permian areas north of the Cobequids. No. 1 is a very productive hay field. No. 2 is virgin soil.

No. 3—is a fairly productive soil from Wentworth Center, Millstone Grit area.

No. 4—is a subsoil from a model orchard at Aspen, Guysboro county.

No. 5a—is an average of 5 soils from the Limestone areas Stewiacke and Musquodobit valleys.

No. 7—is a well cultivated and productive field at Antigonish on the Carboniferous limestone.

No. 8—is from the same geological formation at Wentworth, Cumberland county.

No. 9 is a surface virgin soil from Government farm, Truro.

No. 10—is an upland soil on the Midland railway about eight miles from Truro.

No. 11—From Atlanta, Kings county; an orchard soil.

No. 12—A surface, virgin soil from central Lunenburg.

No. 13—A soil from Hectanooga, Digby county, farm of Father Broque.

TABLE 2—MARSH SOILS.

	1	2	4	q	u	A	G	C	E	F	M	14	H	S	t	13
Insoluble..	84.91	76.77	84.76	82.70	83.66	83.02	77.01	74.92	78.44	78.07	76.24	83.04	75.6	77.23	78.33	75.31
Potash....	.58	.98	.61	.79	.72	.64	.61	1.22	.84	.63	.48	.27	.75	.62	.99	03
Soda......	.48	.53	.78	.64	.82	1.49	1.43	1.24	1.46	.76	88	.57	1.14	1.08	.36	02
Lime	1.05	.7	1.15	.65	.9	1.05	.83	.67	4	6	6	6	3	3	65	4
Magnesia	1.40	2.04	.97	1.23	1.39	1.13	.65	.85	.58	.86	78	.13	4	1.65	1.58	1.17
Sulphuric acid...	.14	.25	.28	.12	.19	.31	.75	.55	.85	.79	.96	.17	8	.11	.09	.61
Iron oxide	7.3	12.2	7.5	9.2	7.7	3.54	5.63	5.45	6.35	8.0	4.5	2.90	5.3	13.1	11.2	4.1
Alumina						3.74	5.45	6.09	4.35	3.44	6.9	4.54	5 4			5.5
Phosphoric acid...	.13	0.18	.05	18.	.1	.18	.27	.34	.21	.21	.19	.21	.25	.16	.16	.19
Volatile or organic	4.22	5.02	3.32	4.29	3.57	3.00	5.00	6.92	4.77	6.01	5.75	4.89	8.12	3.98	5.75	10.43
Moisture .	.27	1.82	.82	1.24	1.1	.71	2.1	.43	1.55	1.5	2 62	1.89	2 12	1.6	1.43	1.86
Nitrogen..	.05	.15	.06	.08	.06	.14	.36	.27	.26	.29	.24	.13	.35	.05	.14	.26

New Deposits of Marsh Mud.

No. 1—from Mr. Carl Church's property, Falmouth.

No. 2—from Mr. C. H. Black's property, Amherst.

No. 4—from Cornwallis River, near Wolfville.

No. q—from Mr. Taggart's farm, Masstown, Colchester county.

No. u—from Gaspereau River, Mr. Patterson's land.

No. A—from Mr. A. C. Layton's property, Great Village.

No. G—from Folly River, Colchester county.

No. C—from Mr. Urquhart's property, Folly; dyked 3 years before and salt marsh grasses being crowded out by timothy, etc.

No. S—taken at depth of 27-36 inches from A. C. Layton's new marsh, Great Village.

Good Dyked Soil.

No. H—Great Village; cropped for ten years with no treatment; at the time of sampling gave 2½ tons hay per acre.

No. t—from same property, ploughed two years before and gave in 1907, four tons hay per acre.

Run out Marsh.

No. E—Old marsh of Mr. Morrison, Folly, Colchester county.

No. F—Old marsh of Mr. Urquhart, Folly, Colchester county, full of weeds.

No. M—Very sour soil: full of weeds: no drainage: Mr. C. T. Smith, Folly.

No. 13—Mr. Patterson's, Horton, Kings county.

No. 14—Mr. C. Logan, Amherst Point: ½ ton hay to the acre.

TABLE 3—SOILS FROM TATAMAGOUCHE AND STEWIACKE.

	22s	16s	6s	11s	17s	7n	13n	2n	12n	9n
Insoluble	85.59	79.56	83.19	80.02	79.33	91.13	85.12	72 15	86.08	65.14
Potash	.28	.32	.36	.42	.4	.19	.21	.39	.29	.55
Soda	.05	.05	.15	09	.08	.06	.13	.27	.15	.48
Lime	.20	.12	.20	.55	.33	.10	.39	.35	.42	.55
Magnesia	1.21	.71	.73	.63	1.0	.37	.66	1 15	.52	.57
Sulphuric Acid	.09	.12	.11	.11	.07	.16	.10	.13	.10	4 32
Iron oxide	2.54	4.61	3.74	3.25	4.15	1.30	2.25	4.45	2.22	8.32
Alumina	3.92	4.85	2.91	5.68	6.66	2.11	2.27	7.64	2.94	.16
Phosphoric acid	.14	.19	.20	.12	.14	.09	.18	.31	.14	.15
Organic	6.54	8.3	8.19	8.51	8.12	4.08	7.96	11.3	6.54	15.6
Moisture	.44	1.24	1.25	1.28	1.74	.71	1.21	2.16	1.41	3.35
Nitrogen	.13	.21	.22	.18	.17	.07	.23	.3	.15	.83
Humus	1 30	2.55	2.75	2.7	2.56	1.65	2.70	3.30	1.85	......

EXPLANATION OF TABLE III.

No. 22s—From worn out hillside, Campbell Brothers, Stewiacke.

No. 16s—Mr. D. W. Reid, Middle Musquodobit; model orchard giving good returns for 25 years; mostly barn manure.

No. 6s—Property of Dr. Reynolds, Otter brook, Stewiacke; old field near river intervale.

No. 11s—Worn out hillside at Mr. E. Hamilton's, Springside, Colchester county.

No. 17s—Middle Musquodobit; the Layton farm, giving fair hay crop with no cultivation.

No. 7n—Pasture, newly broken up and given little bone meal. Mr. J. Cunningham, Bayhead, Colchester county.

No. 13n—Turnip field giving good yield; previously in hay for several years; 40 tons barn manure per acre. Mr. A. P Semple, Brule.

No. 12n—Mr. Jas. Kennedy, Brule; upland not ploughed for 8 years; top dressed once with barn yard manure; yield 2 tons per acre.

No. 2n—McCallum's Settlement; old field.

No. 9n—Run out upland; farm of Wm. Charlton, Stake Road, Cumberland county.

Averaging up these analyses we have:—

TABLE IV.

	Acid Sol. Potash	P_2O_5	Lime	Org.	Nitrogen
16 Marsh soils	.75	.15	.75	6.7	.18
10 Upland	.34	.16	.3	10.	.25
14 of Table I	.2	.14	.25	10.3	.17
Average of 200 fertile surface American soils—					
Snyder	.29	.24	2.16	7.	.29

What is the availability of the plant food in Nova Scotia soils? Four samples collected by the writer and analyzed at Ottawa under the direction of Professor Shutt gave as follows:

	Lime		Potash		Phosphoric acid	
	Acid soluble	Available	Acid soluble	Available	Acid soluble	Available
1—Good soil	1.64	.99	.27	.048	.23	.087
2—Virgin soil	.04	0	.145	.105	.026	.011
3— "	.36	.15	.37	.019	.11	.023
4— "	.11	.02	.42	.018	064	.023

Of the important plant foods nitrogen, lime, phosphoric acid, and potash, consider first potash. We regard it as existing in the soil in the easily soluble or available form; the more difficult soluble or acid soluble and the insoluble part; for example a soil analyzed:

POTASH
Insoluble in acid............... .737%
Acid soluble.................... .149% } .886 % unavailable
Available...................... .02 %

That is, there are 45 times as much insoluble potash as available.

Dyer, in Proc. Royal Society, 1901, says that less than .01 to .03 per cent of available phosphoric acid in a soil indicates the need of phosphate manures and that soils with .01 per cent of available potash probably require no application of potash manures.

Hence, from Dyer's statement and the analyses in Tables 1-5 we can say that our soils have a good supply of potash but available to a limited extent. Comparing soil No. 1, which has a good supply of lime and organic matter, with Nos. 2, 3, and 4, low in these components, one may account for the greater proportion of available potash in No. 1.

Phosphoric Acid.

The total phosphoric acid of the soil exists in a much more easily soluble form than the total potash; the acid soluble phosphoric acid is the total and is found in our soils as shown in the summary, Table 4. The phosphoric acid is, as shown in Table 5, about one-fourth available and therefore soon used either by the plant, or washed away as a sediment.

LIME AND ACID SOILS.

Comparing the percentage of the important constituents with standards given, one notices the deficiency of lime. The lime, CaO, shown in the hydrochloric acid extract may come from dissolving the limestone or the lime silicates; since limestone cannot exist in the presence of acids we are led to test soils for acidity.

Acid Soils.

A simple test for an acid soil is: Place a lump of damp soil on a piece of moistened blue litmus; a reddening shows the presence of acid. Out of sixty-eight soils from upland, intervale, and marsh so tested, only ten showed no acid reaction and of these, six were new marsh deposits; the four only, cultivated soils showing no acid reaction were from areas giving good crops, in one case four tons of hay per acre. Many of the acid soils were from unused fields and some from geological areas showing much limestone rock. Now lime and limestone are the substances which will correct the acidity so we are, from this test, led to infer that our soils need additions of lime. The action of this substance in the soil is very complex and but imperfectly understood.

Since Nova Scotia has many limestone areas, one might expect the soil to be well provided with lime, but such is not the case; it being a land of hills and valleys, of brooks and rivers, the limestone is carried away especially from the light soils of the limestone areas. From the limestone soils of

England, 1429 pounds per acre to the depth of nine inches were carried away in the drainage water per year, or in the forty years of the experiment, about 28 tons per acre.

Limestone has the following uses in the soil:—

(1)   To supply calcium, a necessary element of plant food; 4 tons of clover per crop, for 30 crops would require 3,510 pounds of Calcium.

(2)   To neutralize the acids resulting from the decay of organic material or the decomposition of such fertilizers as ammonium sulphate. Very often the soils with the least organic matter show the least lime and vice versa; e. g., a muck soil at Truro shows at the surface:—

	Inorganic matter.	Volatile matter.	Lime
At surface...........	7%	85.90%	3.20%
1st ft. of subsoil......	79%	15.73%	1.40%

(3)   To effect a chemical dissolving of potash silicates and to set free phosphoric acid from iron and aluminum phosphates.
(4)   For its flocculating effect on the clay soils.

Caustic Lime, CaO, has an antiseptic effect on the soil. Hutchinson of Rothamsted Exp. station, England, in June, 1913, says: "Caustic lime is a valuable antiseptic and when applied to the soil, even in the presence of large quantities of carbonate of lime, disturbs or destroys the state of equilibrium existing between the micro-flora and micro-fauna of the soil; it kills many bacteria and destroys the larger protozoa which exert a depressing effect on bacterial growth; the inhibitory action of caustic lime on soil bacteria persists until all the oxide is changed to the carbonate; this is followed by a period of active bacterial growth.

Organic Matter and Nitrogen.

Table 4 gives averages of the organic matter and nitrogen in the three groups of soil studied: these indicate organic

matter deficient in nitrogen, just as we have in the peat soils much organic matter with little nitrogen; we must say then, that while the organic matter averages fairly well, the nitrogen content is low, there being too much cropping for the amount of nitrogen returned.

Again, these soils are, as a rule, acid; consequently, the bacteria, which break up the organic matter and form nitrates and which cannot work in the presence of acids, are rendered inactive; this brings into question the availability of the nitrogen and suggests the use of a base like lime.

The great problem in Nova Scotia seems to be to increase and maintain the amount of available nitrogen.

The analyses thus far show:—

(1)   That our soils have a good supply of potash but that it is only slightly available.

(2)   That phosphoric acid in many soils is in small amounts, is about one third available and hence soon used.

(3)   That, while volatile matter is quite high, it is deficient in nitrogen.

(4)   That lime is *very deficient* in many soils.

Hopkins of Illinois, in speaking of the average soils of the United States says "Phosphorus is the key to permanent agriculture on these lands."

The recommendation from this study is, if the soil is in fair condition, supply (1) limestone in the powdered form, 2 tons per acre every four years; (2) a mineral phosphate as basic slag, or if obtainable, ground rock phosphate, 600 lbs. per acre every three or four years; this will put the land in condition for growing legumes which, if ploughed under or fed and the manure returned to the land, will increase the store of nitrogen and organic matter. This organic matter will help to dissolve the potash which is present, locked up in the soil.

The Phenology of Nova Scotia, 1913—By A. H. MacKay, Ll.D.

These phenological observations were made in the schools of the province of Nova Scotia as a part of the Nature Study work prescribed. The pupils report or bring in the flowering or other specimens to the teachers when they are first observed. The teachers record the first observation and observer, and vouch for the accurate naming of the species. The schedules from 200 of the best schools form the material of the following system of average dates (phenochrons) for the ten biological regions of the Province, and the phenochrons of the Province as a whole. The compilation of the 200 schedules was done by H. R. Shinner, B. A.

The Province is divided into its main climate slopes or regions not always coterminous with the boundaries of counties. Slopes, especially those to the coast, are subdivided into belts, such as (a) the coast belt, (b) the low inland belt, and (c) the high inland belt, as below:—

No.	Regions or Slopes.	Belts.
I.	Yarmouth and Digby Counties,	(a) Coast, (b) Low Inlands, (c) High Inlands.
II.	Shelburne, Queens & Lunenburg Co's.	" " "
III.	Annapolis and Kings Couties,	(a) Coast, (b) North Mt., (c) Anapolis Valley, (d) Cornwallis Valley, (e) South Mt.
IV.	Hants and Colchester Counties,	(a) Coast, (b) Low Inlands, (c) High Inlands.
V.	Halifax and Guysboro Counties,	" " "
VI.A.	Cobequid Slope (to the south),	" " "
VI.B.	Chignecto Slope (to the northwest),	" " "
VII.	Northumberland Stp Slope (to the n'h)	" " "
VIII.	Richmond & Cape Breton Co's.,	" " "
IX.	Bras d'Or Slope (to the southeast),	" " "
X.	Inqerness Slope (to Gulf, N. W.),	" " "

The ten *regions* are indicated on the outline map on the next page.

(347)

BAY of FUNDY

NORTHUMBERLAND STRAIT

ATLANTIC OCEAN

SCALE 67½ MILES TO 1 INCH

67½
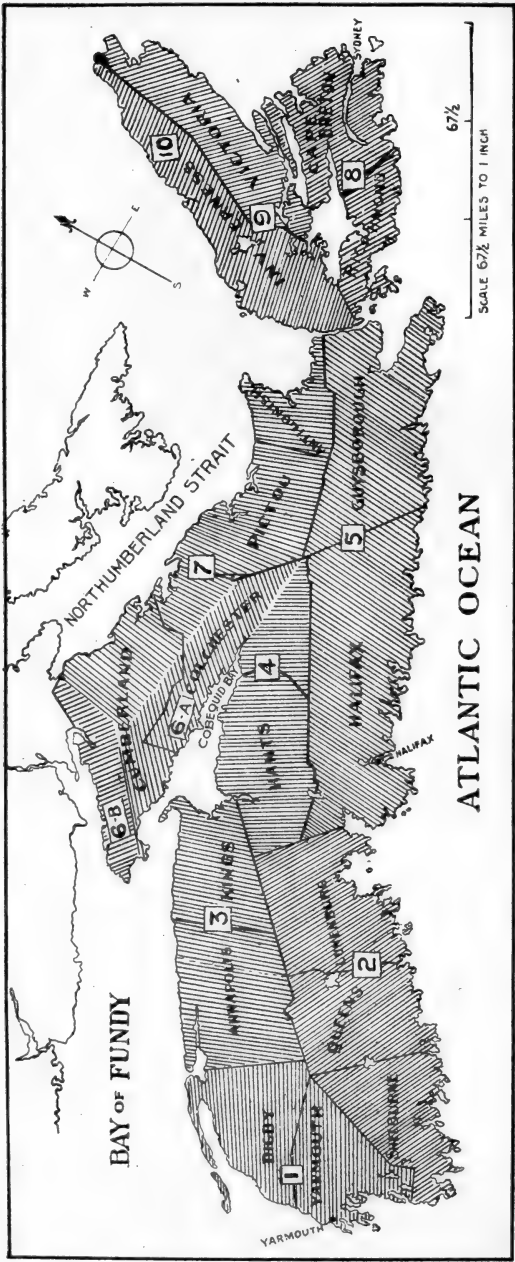
THE TEN PHENOLOGICAL REGIONS OF NOVA SCOTIA.

THE PHENOLOGY OF NOVA SCOTIA, 1913.

[Compiled from over 200 local observation schedules.]

YEAR 1913.

Day of the year corresponding to the last day of each month.

Jan.	31	July	212
Feb.	59	Aug.	243
March	90	Sept.	273
April	120	Oct.	304
May	151	Nov.	334
June	181	Dec.	365

For leap year add one to each except January.

Species list

1. Alnus incana, Wild.
2. Populus tremuloides.
3. Epigea repens, L.
4. Equisetum arvense.
5. Sanguinaria Canadensis.
6. Viola blanda.
7. Viola palmata, cucullata.
8. Hepatica triloba, etc.
9. Acer rubrum.
10. Fragaria Virginianum.
11. "   "   fruit ripe.
12. Taraxacum officinale.
13. Erythronium Americanum.
14. Coptis trifolia.
15. Claytonia Caroliniana.
16. Nepeta Glechoma.

WHEN FIRST SEEN — Observation Regions

#	Avg. Dates	10. Inverness Slope to Gulf	9. Bras d'Or Slope, Inv. and Victoria	8. Richmond and Cape Breton	7. N.Cumb., Col, Picton and Antigonish	6. S. Cobequid Slope, (S. Cum. & Col.)	5. Halifax and Guysboro	4. Hants and South Colchester	3. Annapolis and Kings	2. Shelburne, Queens and Lunenburg	1. Yarmouth and Digby
1	103	110	110	111	98	100	117	96	101	93	94
2	114	123	123	114	109	100	125	115	98	107	
3	102	110	110	112	217	104	103	104	98	92	85
4	116	123	123	126	119	121	123	121	117	113	115
5	135	158	158	132	118	119		125	140	130	
6	116	119	119	119	117	117	115	119	117	114	112
7	121	124	124	126	120	120	123	122	117	118	114
8	127	128	128	134	116	121	125	123	150	116	117
9	117	121	121	129	120	119	120	121	116	116	116
10	120	121	121	172	120	168	163	119	116	117	117
11	119	166	121	130	124	125	163	125	121	117	158
12	123	127	127	131	123	124	125	124	159	149	114
13	126	130	130	131	121	127	157	128	117	119	118
14	126	120	120	143	121	115	129	124	155	125	118
15	126	126	126	121	121	139	129	123	136	123	128
16	133	126	126	146	129		132	123	160		

WHEN BECOMING COMMON — Observation Regions

#	Avg. Dates	1. Yarmouth and Digby	2. Shelburne, Queens and Lunenburg	3. Annapolis and Kings	4. Hants and South Colchester	5. Halifax and Guysboro	6. S. Cobequid Slope, (S. Cum. & Col.)	7. N.Cumb., Col, Picton and Antigonish	8. Richmond and Cape Breton	9. Bras d'Or Slope, Inv. and Victoria	10. Inverness Slope to Gulf
1	111	104	101	113	104	120	109	102	118	120	120
2	123		117	107	121	132		114	121	136	136
3	111	102	102	109	112	111	115	115	118	116	116
4	126	121	120	126	128	129	128	125	132	128	128
5	138		130	145	130		122	124	135	158	158
6	123	123	120	123	1.24	123	123	121	132	126	126
7	128	123	123	126	127	130	129	121	132	131	131
8	131		116	153	131	133		122	138	128	128
9	126	122	126	121	128	129	130	124	132	126	126
10	128	125	125	129	127	128	131	128	175	130	130
11	172	173	121	171	173	175	172	171	135	171	171
12	130	128	123	127	131	131	133	130	152	134	134
13	143	135	126	158	134	159	133	128	138	134	134
14	133	130	125	131	131	132	133	136	149	129	129
15	132		129	142		135	133	126		131	
16	141	156	129	163	130	134	145	136	150	131	131

THE PHENOLOGY OF NOVA SCOTIA, 1913.—Continued.

YEAR 1913

Day of the year corresponding to the last day of each month.

Jan.........31		July.........212
Feb.........59		Aug.........243
March.......90		Sept........273
April.......120		Oct.........304
May.........151		Nov.........334
June........181		Dec.........365

For leap year add one to each except January.

WHEN BECOMING COMMON — Observation Regions

Regions: 1. Yarmouth and Digby; 2. Shelburne, Queens and Lunenburg; 3. Annapolis and Kings; 4. Hants and South Colchester; 5. Halifax and Guysboro; 6. Cobequid Slope (S. Cum. & Col.); 7. N. Cumb., Col., Pictou and Antigonish; 8. Richmond and Cape Breton; 9. Bras d'Or Slope, Inv. and Victoria; 10. Inverness Slope to Gulf.

#	Species	1	2	3	4	5	6	7	8	9	10	Avg
17	Amelanchier Canadensis	132	132	134	136	138	137	134	148	143	143	138
18	" fruit ripe		230		130	166		148	158			168
19	Prunus Pennsylvanica	136	142	139	145	140	145	140	240	151	151	145
20	" fruit ripe								247			240
21	Vaccinium Can. and Penn.	134	133	136	144	143	143	143	163	159	159	145
22	" fruit ripe		174		148	156		166	168			180
23	Ranunculus acris	151	152	154	163	156	153	157	156	164	164	156
24	R. repens	148	147	155	161	161	157	164	156	163	163	159
25	Trill. erythrocarpum	161	139	143	150	158	147	149	165	163	163	153
26	Rhododendron Rhodora	139	152	145	147	154	139	151	165	154	154	149
27	Cornus Canadensis	152	225	143	156	156	155	155	207	153	153	154
28	" fruit ripe		154	175	154	161		151	156			184
29	Trientalis Americana	144	156	153	163	157	154	157	171	149	149	152
30	Clintonia borealis	157	164	153	162	166	161	160	174			159
31	Calla palustris	162	159	170	165	158	159	164	167	170	170	165
32	Cypripedium acaule	162	165	159	166	166	162	163	163	172	172	165
33	Sisyrinchium angustifolium	162	164	159	172	172	162	154	166	157	157	165
34	Linnaea borealis	160	167	148	155	157	165	163	176	171	171	164
35	Kalmia glauca	150	162	158	162	165	158	163	162	171	171	159
36	Kalmia augustifolia	163	165	159	166	166	164	165	176	168	168	163
37	Crataegus oxyacantha	163	165	161	170	170	162	162	176	167	167	166
38	Crataegus coccinea, etc.	164	162	163	170	173	171	170	176	170	170	164
39	Iris versicolor	165	165	171	168	161		170	172	170	170	168
40	Chrysanthemum Leucanthmum	166	166					170		178	178	172
41	Nuphar advena	172	170	155				170		170	170	167

WHEN FIRST SEEN — Observation Regions

Regions: 1. Yarmouth and Digby; 2. Shelburne, Queens and Lunenburg; 3. Annapolis and Kings; 4. Hants and South Colchester; 5. Halifax and Guysboro; 6. Cobequid Slope (S. Cum. & Col.); 7. N. Cumb., Col., Pictou and Antigonish; 8. Richmond and Cape Breton; 9. Bras d'Or Slope, Inv. and Victoria; 10. Inverness Slope to Gulf.

#	Species	Avg	1	2	3	4	5	6	7	8	9	10
17	Amelanchier Canadensis	131	127	128	126	131	138	130	123	144	135	135
18	" fruit ripe	159		204		125	166		143	152		
19	Prunus Pennsylvanica	139	126	137	134	139	140	135	134	222	148	148
20	" fruit ripe	222								222		
21	Vaccinium Can. and Penn.	170	123	125	128	136	136	136	134	152	153	153
22	" fruit ripe	137	139	174	139	145	152		165	222	153	153
23	Ranunculus acris	148	140	145	146	155	159	143	148	156	153	153
24	R. repens	153	145	143	145	143	159	152	156	164	158	158
25	Trill. erythrocarpum	147	150	143	137	150	149	138	143	154	158	158
26	Rhododendron Rhodora	144	131	145	138	150	151	144	146	154	151	151
27	Cornus Canadensis	146	139	145	136	146	151	149	149	151	146	146
28	" fruit ripe	173	141	208	170	154	157	147	145	183	147	147
29	Trientalis Americana	147	152	147	149	160	151	156	150	155		
30	Clintonia borealis	153	156	150	168	160	157		160	168		
31	Calla palustris	160	156	152	148	167	162	151	157	170	164	164
32	Cypripedium acaule	158	156	159	153	150	161	160	159	171	162	162
33	Sisyrinchium angustifolium	158	159	165	145	159	168	160	162	166	151	151
34	Linnaea borealis	160	141	159	144	147	154	152	144	161	161	161
35	Kalmia glauca	152	157	160	157	159	160	162	157	175	160	160
36	Kalmia augustifolia	158	157	158	154	158	163	165	158	156	167	167
37	Crataegus oxyacantha	160	157	158	160	158	162	157	155	174	169	169
38	Crataegus coccinea, etc.	160	161	158	160	165	166	162	166	171	175	175
39	Iris versicolor	164	157	158	166	164	167	157	166	175	175	175
40	Chrysanthemum Leucanthmum	167	157	158	166	162			166	176	160	160
41	Nuphar advena	161	164	163	154				160	170	160	160

No.		
42	Rubus strigosus.... fruit ripe	
43	Rhinanthus Crista-galli.	
44	Rubus villosus.... fruit ripe	
45		
46		
47	Sarracenia purpurea.	
48	Brunella vulgaris.	
49	Rosa lucida.	
50	Leontodon autumnale	
51	Linaria vulgaris.	
52	Trees appear green.	
53	Ribes rubrum cultivated	
54	" fruit ripe	
55	R. nigrum cultivated	
56	" fruit ripe	
57	Prunus Cerasus.... fruit ripe	
58		
59	Prunus domestica.	
60	Pyrus Malus.	
61	Syringa vulgaris.	
62	Trifolium repens.	
63	Trifolium pratense.	
64	Phleum pratense.	
65	Solanum tuberosum.	
66	Ploughing (first of season).	
67	Sowing	
68	Potato-planting.	
69	Sheep-shearing.	
70	Hay-cutting.	
71	Grain-cutting.	
72	Potato-digging.	
73a	Opening of rivers.	
73b	Opening of lakes.	
74a	Last snow to whiten ground.	
74b	" fly in air.	
75a	Last spring frost—hard	
75b	" —hoar	
76a	Water in streams—high	
76b	" —low	
77a	First autumn frost—hoar	
77b	" —hard	
78a	First snow to fly in air.	
78b	" whiten ground.	
79a	Closing of lakes.	
79b	" rivers.	
81a	Wild ducks migrating, N.	
81b	" S.	
82a	Wild geese migrating N	

THE PHENOLOGY OF NOVA SCOTIA, 1913.—*Continued.*

YEAR 1913.

Day of the year corresponding to the last day of each month.

Month	Day
Jan.	31
Feb.	59
March	90
April	120
May	151
June	181
July	212
Aug.	243
Sept.	273
Oct.	304
Nov.	365

For leap year add one to each except January.

WHEN FIRST SEEN. — OBSERVATION REGIONS

#	Species	Avg. Dates	10. Inverness Slope to Gulf	9. Bras d'Or Slope, Inv. and Victoria	8. Richmond and Cape Breton	7. N. Cumb., Col., Picton and Antigonish	6. S. Cobequid Slope (S. Cumb. & Col.)	5. Halifax and Guysboro	4. Hants and South Colchester	3. Annapolis and Kings	2. Shelburne, Queens and Lunenburg	1. Yarmouth and Digby
82b	Wild geese migrating (S. North.)	301	99	99	298	291		94	86	283	349	284
83	Melospiza fasciata	93	85	85	94	87	106	73	79	79	79	111
84	Turdus migratorius	75	91	91	70	79	62	80	75	68	76	70
85	Junco hiemalis	89	170	117	87	92	70	123	131	163	66	79
86	Actitis macularia	121	118	118	139	124		121	120	100	117	121
87	Sturnella magna	128			135	124	116	152	134	87	126	126
88	Ceryle Alcyon	117	131	131	137	115	117	151	134	102	121	118
89	Dendroeca coronata	121	139	139	148	134	124	186	124	104	152	120
90	D. æstiva	135	143	143	142	140	142	139	131	133	140	136
91	Zonotrichia alba	124			151	127	115	131	131	100	125	160
92	Trochilus colubris	146	124	124	160	141	141	140	138	145	152	110
93	Tyrannus Carolinensis	135	118	118	125	141	114	120	153	106	160	94
94	Dolychonyx oryzivorus	124	114	114	143	136	115	123	123	104	110	
95	Spinis tristis	125	114	114	180	144	100	146		91	94	113
96	Setophaga ruticilla	131	142	142	141	154	107	121		90	122	89
97	Ampelis cedrorum	132	107	107	104	156		100	123	125	150	80
98	Chordeiles Virginianus	130	116	116	110	138		106	108	95	137	
99	First piping of frogs	97				96					84	
100	First appearance, snakes	105				109				106	93	

WHEN BECOMING COMMON. — OBSERVATION REGIONS

(No entries recorded for regions 1–10 or Average Dates in this section.)

Thunderstorms—Phenological Observations, Nova Scotia, 1913.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

Observation Regions.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Total Year 1913.
.....	.....	.....	.....	.....	.....	3	.....	.....	.....	3
.....	7	.....	.....	.....	.....	.....	.....	.....	.....	7
8[2]	8[6]	8	.....	.....	.....	.....	.....	.....	.....	8[9]
.....	.....	.....	12	12	.....	.....	.....	.....	.....	12[2]
.....	13[2]	.....	.....	.....	.....	.....	.....	.....	.....	13[2]
.....	.....	.....	.....	.....	14	.....	.....	.....	.....	14
.....	18	.....	18	18	18	.....	.....	.....	.....	18[4]
.....	.....	.....	19	19	.....	.....	.....	.....	.....	19[2]
.....	26	.....	26	.....	.....	.....	.....	.....	.....	26[2]
.....	27[2]	.....	.....	.....	.....	.....	27	.....	.....	27[3]
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	31
.....	.....	.....	.....	39	.....	.....	.....	.....	.....	39
.....	.....	.....	.....	50	.....	.....	.....	.....	.....	50
.....	53[2]	.....	.....	53	.....	.....	.....	.....	.....	53[3]
.....	.....	.....	.....	.....	.....	.....	.....	63	63	63[2]
.....	.....	.....	.....	.....	.....	.....	64	.....	.....	64
.....	65	.....	.....	.....	65	.....	65[6]	65	65	65[10]
.....	70	.....	.....	.....	.....	.....	70	.....	.....	70[2]
.....	.....	.....	.....	.....	.....	73	.....	.....	.....	73
74[2]	74[5]	.....	74[2]	.....	.....	.....	.....	.....	.....	74[9]
75	75	75[4]	75	.....	.....	75[3]	75	.....	.....	75[11]
.....	.....	.....	.....	78	.....	.....	.....	.....	.....	78
.....	.....	.....	.....	.....	.....	84	84[2]	.....	.....	84[3]
.....	.....	.....	87	.....	.....	.....	.....	.....	.....	87
.....	.....	.....	.....	88	.....	.....	.....	.....	.....	88
.....	.....	.....	.....	.....	.....	90	.....	.....	.....	90
95	95[3]	.....	.....	95	.....	.....	.....	.....	.....	95[5]
.....	.....	.....	.....	96	.....	.....	.....	.....	.....	96
.....	.....	.....	.....	102	.....	.....	.....	.....	.....	102
.....	105	.....	.....	.....	.....	.....	.....	.....	.....	105
.....	.....	.....	.....	.....	.....	106	.....	.....	.....	106
.....	.....	107	.....	107[3]	.....	.....	.....	.....	.....	107[4]
.....	108	.....	.....	.....	.....	.....	.....	.....	.....	108
109[5]	109[19]	109	109	.....	.....	.....	.....	.....	.....	109[26]
.....	110	.....	.....	.....	110	.....	.....	.....	.....	110[2]
.....	.....	.....	.....	.....	.....	111	.....	.....	.....	111
115	115	.....	115	.....	.....	115	.....	.....	.....	115[4]
.....	.....	.....	.....	.....	.....	116	.....	.....	.....	116
.....	117[3]	117[5]	117[6]	.....	117[2]	117[4]	.....	.....	.....	117[20]

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1913.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION REGIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness slope to Gulf.	Total Year 1913.
			118^{12}	118^{5}	118^{6}	118^{4}				118^{27}
	119			119	119^{2}	119^{6}				119^{10}
								121	121	121^{2}
127	127		127							127^{3}
	128									128
				129						129
							133			133
134			134^{2}		134					134^{4}
			135^{2}			135				135^{3}
				138						138
	139		139^{12}	139^{4}		139^{9}	139	139^{4}	139^{4}	139^{35}
			140^{2}					140	140	140^{4}
		146				146				146^{2}
						147				147
						148^{2}				148^{2}
149^{5}	149^{7}	149^{5}								149^{17}
153	153^{5}		153^{2}					153	153	153^{10}
					153^{3}					154^{3}
	155^{10}	155^{3}	155^{3}	155^{5}		155	155			155^{25}
		156	156^{2}							156^{3}
	157									157
	158	158^{2}	158^{2}			158				158^{6}
	159		159			159				159^{3}
			160							160
							164			164
					165^{2}		165			165^{4}
167^{4}	167^{22}	167^{7}	167^{7}	167^{5}	167	167	167	167	167	167^{50}
			168	168						168^{2}
	169^{5}									169^{5}
	170^{10}	170	170^{7}	170^{3}		170		170^{2}	170^{2}	170^{26}
			171							171
	172									172
	173^{2}			173			173^{10}	173^{2}	173^{2}	173^{17}
						176				176
	178^{8}	178^{2}	178^{2}	178	178^{2}	178				178^{16}
						179				179
		181								181
							185			185
							195			195

Thunderstorms—Phenological Observations, N.S., 1913.—*Continued.*

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

Observation Regions.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness slope to Gulf.	Total Year 1913.
							201			201
							202²			202²
							216			216
							221			221
							222²			222²
	231									231
	239²	239²								239⁴
	240		240			240³	240			240⁶
						242				242
	246	246								246²
						247				247
	251²	251								251³
						255	255³			255⁴
						270				270
			274							274
	275		275	275		275				275⁴
		276								276
277²	277									277³
		281								281
	286									286
	289²			289		189				289⁴
						290				290
						294				294
300										300
			301			301				301²
304										304
								308		308
		311								311
	314									314
			315							315
	344									344

APPENDIX I.

LIST OF MEMBERS, 1910-11.

ORDINARY MEMBERS.

Date of Admission

Bancroft, George R., Academy, Halifax..........................Jan. 7, 1908
Bishop, Watson L., Supt. Waterworks, Dartmouth, _ . S.. ....Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax ....Mar. 13, 1884
Bronson, Prof. Howard Logan, PH. D., Dalhousie College, Halifax ..Mar. 9, 1911
Brown, Richard H., Halifax ....Feb. 2, 1903
Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax..Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax ....Jan. 31, 1890
Campbell, George Murray, M. D., Halifax ....Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax ....Feb. 2, 1903
Creighton, Henry Jermain Maude, M. A., M. SC., DR. SC., F. C. S.,
         Zürich, Switzerland. ....Jan. 7, 1908
*Davis, Charles Henry, C. E., New York City, U. S. A. ....Dec. 5, 1900
Davis, Harold, S., B. A., Dalhousie College Halifax.. ....Mar. 9, 1911
Doane, Francis William Whitney, City Engineer, Halifax ....Nov. 3, 1886
Donkin, Hiram, M. E., Deputy Com. of Mines, Halifax ....Nov. 30, 1892
Fergusson, Donald M., chemist, Acadia Sugar Ref. Co., Halifax ....Jan. 5, 1909
*Forbes, John, Halifax ....Mar. 14, 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax..Mar. 31 1890
Freeman, Philip A., Hx. Elect. Tramway Co., Halifax ....Nov. 6, 1906
Harlow, A. C., Morris Street School, Halifax ....Jan. 7, 1908
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth. ...Nov. 12, 1892
Hayward, A. A., Halifax ....Nov. 7, 1905
Howe, Prof. Clarence D., B. SC., Dalhousie College, Halifax.. .....Mar. 9, 1911
Irving, G. W. T., Education Dept., Halifax ....Jan. 4, 1892
Johnston, Harry W., C. E., Asst. City Engineer, Halifax ....Dec. 31, 1894
Kelly, Rev. M. C., St. Mary's College, Halifax.. ....Jan. 4, 1910
*Laing, Rev. Robert, Halifax ....Jan. 11, 1885
McCallum, A. L., B. SC., analyst, Halifax ....Jan. 7, 1908
McCarthy, Prof. J. B., B. A., M. SC.. King's College, Windsor, N. S...Dec. 4, 1901
McColl, Roderick, C. E., Provincial Engineer, Halifax...........Jan. 4, 1892
*MacGregor, Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C.,
         Edinburgh University, Edinburgh, Scotland ....Jan. 11, 1877
McInnes, Hector, LL. B., Halifax ....Nov. 27, 1889
MacIntosh, Donald Sutherland, B. A., M. SC., Dalhousie Col., Halifax ..Mar. 9, 1911
*McKay, Alexander, M. A., Supervisor of Schools, Halifax.........Feb. 5, 1872
*MacKay, Alexander Howard, B. A., B. SC., LL. D., F. R. S. C., Superin-
         tendent of Education, Halifax ....Oct. 11, 1885
Mackay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax ....Nov. 27, 1889
*MacKay, George M. Johnstone, Shenectady, N. Y., U. S. A........Dec. 18, 1903
MacKenzie, Prof. Arthur Stanley, PH. D., Dalhousie College, Halifax .Nov. 7, 1905
McKerron, William, Halifax ....Nov. 30, 1891
McLearn, F. H., B. A., Halifax ....Oct. 14, 1908
McNeill, Prof. Murray, Dalhousie College......................Jan. 7. 1908

*Life Members.

Date of Admission

Marshall, Guilford R., B. A., Halifax ....Apr. 4, 1894
Moore, Prof. Clarence L., M. A., Dalhousie College, Halifax ....Jan. 7, 1908
Morton, S. A., M. A., County Academy, Halifax ....Jan. 27, 1893
Murray, Prof. Daniel Alexander, PH. D., Montreal ....Dec. 18, 1903
Nickerson, Carleton Bell, M. A., Dalhousie College, Halifax. ....Mar. 9, 1911
Pickings, H. B., Mines Department, Halifax ....May 6, 1908
Piers, Harry, Curator Provincial Museum and Librarian Provincial
    Science Library, Halifax ....Nov. 2. 1888
*Poole, Henry Skeffington, A. M. ASSOC. R. S. M., F. G. S., F. R. S. C.,
    CAN. SOC. C. E., HON MEM. INST. M. E., Guildford, Surrey,
    England ....Nov. 11, 1872
*Robb, D. W., Amherst, N. S. ....Mar. 4, 1890
Robinson, Ernest, B. A., Canning, N. S........................Jan. 7, 1908
Rutherford, John, M. E., Halifax ....Jan. 8, 1865
Sexton, Prof. Frederic H., Director of Technical Education, Halifax..Dec. 18, 1903
*Smith, Prof. H. W. B. SC., Agricultural College, Truro, N. S.;
    Assoc. Memb., Jan. 6, 1890 ....Dec. 1900
Stapleton, W. C., B. A., Supervisor of Schools, Dartmouth, N. S. ....Oct. 14, 1908
*Stewart, John, M. B. C. M., Halifax ....Jan. 12, 1885
Wilson, Robert J., Secretary, School Board, Halifax ....May 3. 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax ....Dec. 18, 1903
Woodman, Prof. J. Edmund, M. A., D. SC., New York University,
    New York, U. S. A. ....Dec. 3, 1902
*Yorston, W. G., C. E., City Engineer, Sydney, C. B. ....Nov. 12, 1892

ASSOCIATE MEMBERS.

Brodie, W. S., B. A., Lunenburg, N. S. ....May 7, 1909
*Caie, Robert, Yarmouth, N. S. ....Jan. 31, 1890
Edwards, Arthur M., M. D., F. L. S., Newark, N. J. ....Dec. 12, 1898
Haley, Prof. Frank R., Acadia College, Wolfville, N. S. ....Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S. ....Mar. 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S. ....May 17, 1899
James, C. C., M. A., Deputy Min. of Agriculture, Toronto, Ontario ...Dec. 3, 1896
Jennison, W. F., Truro, N. S. ....May 5, 1903
*Johns, Thomas W., Yarmouth, N. S. ....Nov. 27, 1889
*Keating, E. H., C. E., Toronto, Ont.; Ordin. Memb., April 12, 1882..Apr. 11, 1900
*MacKay, Hector H., M. D., New Glasgow, N. S. ....Feb. 4, 1902
Magee, W. H., PH. D., Annapolis, N. S. ....Nov. 29, 1894
Payzant, E. N., M. D., Wolfville, N. S. ....Apr. 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S. ....Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis, N. S. ....Jan. 31, 1890
*Robinson, C. B., PH. D., New York Botanical Garden, New York,
    U. S. A. ....Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S. ....Nov. 29, 1894

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*Life Members.

CORRESPONDING MEMBERS.

Date of Admission

Ami, Henry M., D. SC., F. G. S., F. R. S. C., Geological Survey, Ottawa
    Ontario ....Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. C. S., Fredericton, N. B. ...Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S. ....Nov. 29, 1871
Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C., Ontario Agri-
    cultural College, Guelph, Ont. ....Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Fredericton, N. B. ....Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England ....Dec. 3, 1897
Faribault, E. Rodolphe, B. A., B. SQ., Geological Survey of Canada,
    Ottawa ; Assoc. Memb., March 6, 1888 ....Dec. 3, 1902
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton,
    Mass., U. S. A. ....Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England. (Sole sur-
    viving Foundation Member ; originally elected Dec. 26, 1862,
    and admitted Jan. 26, 1862.) ....Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa ..May 5, 1896
Hay, George U., D. SC., F. R. S. C., St. John, N. B. ....Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia ....May 5, 1892
Matthew, G. F., M. A., D. SC., LL. D., F. R. S. C., St. John, N. B. ....Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A. ....Nov. 30, 1891
Mowbray, Louis L., Hamilton, Bermuda ....May 3, 1907
Peter, Rev. Brother Junian ....Dec. 12, 1898
Prest, Walter Henry, M. E., Bedford, N. S. ; Assoc. Memb., Nov.
    29, 1894 ....Nov. 2, 1900
Prichard, Arthur H. Cooper, Librarian, Numismatic Museum, New
    York, U. S. A. ....Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries,
    Ottawa, Ontario. ....Jan. 5, 1897

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION ON 31ST DECEMBER, 1862.

	Term of Office.			
Hon. Philip Carteret Hill, D. C. L.	31 Dec.	1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct.	1863	"	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct.	1873	"	9 Oct. 1878
William Gossip	9 Oct.	1878	"	13 Oct. 1880
John Somers, M. D.	13 Oct.	1880	"	26 Oct. 1883
Robert Morrow	26 Oct.	1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct.	1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M. A., D. SC., F.R.S., F.R.S.C.	10 Oct.	1888	"	9 Nov. 1891
Martin Murphy, C. E., D. SC., I. S. O.	9 Nov.	1891	"	8 Nov. 1893
Prof. George Lawson, PH. D., LL. D., F. I. C., F. R. S. C.	8 Nov.	1893	"	10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov.	1895	"	8 Nov. 1897
Alexander McKay M. A.	8 Nov.	1897	"	20 Nov. 1899
Alexander Howard MacKay, B. A., B. SC., LL. D., F. R. S. C.	20 Nov.	1899	"	24 Nov. 1902
Henry Skeffington Poole, M A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov.	1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct.	1905	"	11 Nov. 1907
Prof. Ebenezer Mackay, PH. D.	11 Nov.	1907	"	12 Dec. 1910
Watson L. Bishop	12 Dec.	1910	"	————

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its Transactions from 4th January to 3rd December, 1859) had led up to the establishment of the N. S. Institute of Natural Science in December, 1862.

APPENDIX II.

LIST OF MEMBERS, 1911-12.

ORDINARY MEMBERS.

Date of Admission

Bancroft, George R., Academy, Halifax.........................Jan. 7, 1908

Barnes, Albert Johnson, B. SC., service inspector Maritime Telephone
  & Telegraph Co., Halifax. ....May 13, 1912

Bishop, Watson L., Supt. Waterworks, Dartmouth, .. S.. ....Jan. 6, 1890

Bowman, Maynard, B. A., Public Analyst, Halifax ....Mar. 13, 1884

Bronson, Prof. Howard Logan, PH. D., Dalhousie College, Halifax ..Mar. 9, 1911

Brown, Richard H., Halifax ....Feb. 2, 1903

Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax..Oct. 30, 1903

*Campbell, Donald A., M. D., Halifax ....Jan. 31, 1890

Campbell, George Murray, M. D., Halifax ....Nov. 10, 1884

Colpitt, Parker R., City Electrician, Halifax ....Feb. 2, 1903

Creighton, Henry Jermain Maude, M. A., M. SC., DR. SC., F. C. S.,
  Dalhousie College, Halifax ....Jan. 7, 1908

*Davis, Charles Henry, C. E., New York City, U. S. A. ....Dec. 5, 1900

Davis, Harold, S., B. A., Dalhousie College Halifax..............Mar. 9, 1911

Doane, Francis William Whitney, City Engineer, Halifax ....Nov. 3, 1886

Donkin, Hiram, M. E., Deputy Com. of Mines, Halifax ....Nov. 30, 1892

Fergusson, Donald M., chemist, Acadia Sugar Ref. Co., Halifax ....Jan. 5, 1909

*Forbes, John, Halifax ....Mar. 14, 1883

*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax..Mar. 31, 1890

Freeman, Philip A., Hx. Elect. Tramway Co., Halifax ....Nov. 6, 1906

Harlow, A. C., Montreal ....Jan. 7, 1908

Harris, Prof. David Fraser, M. D., D. SC., F. R. S. E., Dalhousie
  College, Halifax. ....Feb. 20, 1912

Hattie William Harrop, M. D., Supt. N. S. Hospital, Dartmouth. ...Nov. 12, 1892

Hayward, A. A., Halifax ....Nov. 7, 1905

Howe, Prof. Clarence D., B. SC., Dalhousie College, Halifax.......Mar. 9, 1911

Irving, G. W. T., Education Dept., Halifax ....Jan. 4, 1892

Johnston, Harry W., C. E., Asst. City Engineer, Halifax ....Dec. 31, 1894

Kelly, Rev. M. C., St. Mary's College, Halifax.. ....Jan. 4, 1910

*Laing, Rev. Robert, Halifax ....Jan. 11, 1885

McCallum, A. L., B. SC., analyst, Halifax......................Jan. 7, 1908

McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S..Dec. 4, 1901

McColl, Roderick, C. E., Provincial Engineer, Halifax.............Jan. 4, 1892

*MacGregor, Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C.,
  Edinburgh University, Edinburgh, Scotland ....Jan. 11, 1877

McInnes, Hector, LL. B., Halifax ....Nov. 27, 1889

MacIntosh, Donald Sutherland, B. A., M. SC., Dalhousie Col., Halifax ..Mar. 9, 1911

*McKay, Alexander, M. A., Supervisor of Schools, Halifax.........Feb. 5, 1872

*MacKay, Alexander Howard, B. A., B. SC., LL. D., F. R. S. C., Superin-
  tendent of Education, Halifax ....Oct. 11, 1885

Mackay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax ....Nov. 27, 1889

*MacKay, George M. Johnstone, Shenectady, N. Y., U. S. A.......Dec. 18, 1903

MacKenzie, Prof. Arthur Stanley, PH. D., Dalhousie College, Halifax .Nov 7, 1905

McKerron, William, Halifax ....Nov. 30, 1891

McLearn, F. H., B. A. ....Oct. 14, 1908

McNeill, Prof. Murray, Dalhousie College........ ....Jan. 7, 1908

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*Life Members.

Date of Admission

Marshall, Guilford R., B. A., Halifax ....Apr. 4, 1894
Moore, Prof. Clarence L., M. A., Dalhousie College, Halifax ....Jan. 7, 1908
Morton, S. A., M. A., County Academy, Halifax ....Jan. 27, 1893
Murray, Prof. Daniel Alexander, PH. D., Montreal ....Dec. 18, 1903
Nickerson, Carleton Bell, M. A., Dalhousie College, Halifax........Mar. 9, 1911
Pickings, H. B., Mines Department, Halifax ....May 6, 1908
Piers, Harry, Curator Provincial Museum and Librarian Provincial
     Science Library, Halifax ....Nov. 2 1888
*Poole, Henry Skeffington, A. M. ASSOC. R. S. M., F. G. S., F. R. S. C.,
     CAN. SOC. C. E., HON MEM. INST. M. E·, Guildford, Surrey,
     England ....Nov. 11, 1872
*Robb, D. W., Amherst, N. S. ....Mar. 4, 1890
Robinson, Ernest, B. A., Canning, N. S........................Jan. 7, 1908
Rutherford, John, M. E., Halifax ....Jan. 8, 1865
Sexton, Prof. Frederic H., Director of Technical Education, Halifax..Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural College, Truro N. S.;
     Assoc. Memb., Jan. 6, 1890 ....Dec.   1900
Stapleton, W. C., B. A., Supervisor of Schools, Dartmouth, N. S. ....Oct. 14, 1908
*Stewart, John, M. B. C. M., Halifax ....Jan. 12, 1885
Wilson, Robert J., Secretary, School Board, Halifax ....May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax ....Dec. 18, 1903
Woodman, Prof. J. Edmund, M. A., D. SC., New York University,
     New York, U. S. A. ....Dec. 3, 1902
*Yorston, W. G., C. E., City Engineer, Sydney, C. B. ....Nov. 12, 1892

ASSOCIATE MEMBERS.

Brodie, W. S., B. A., Lunenburg, N. S. ....May 7, 1909
*Caie, Robert, Yarmouth, N. S. ....Jan. 31, 1890
Connolly, Prof. J. C. PH. D., St. Francis Xavier, Antigonish, N. S..Nov. 5, 1911
Edwards, Arthur M., M. D., F. L. S., Newark, N. J. ....Dec. 12, 1898
Haley, Prof. Frank R., Acadia College, Wolfville, N. S. ....Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S..........Mar. 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S. ....May 17, 1899
James, C. C., M. A., Deputy Min. of Agriculture, Toronto, Ontario ...Dec. 3, 1896
Jennison, W. F., Truro, N. S. ....May 5, 1903
*Johns, Thomas W., Yarmouth, N. S. ....Nov. 27, 1889
*MacKay, Hector H., M. D., New Glasgow, N. S. ....Feb. 4, 1902
Magee, W. H., PH. D., Annapolis, N. S. ....Iov. 29, 1894
Payzant, E. N., M. D., Wolfville, N. S. ....Apr. 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S. ....Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis, N. S. ....Jan. 31, 1890
*Robinson, C. B., PH. D., New York Botanical Garden, New York,
     U. S. A. ....Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S. ....Nov. 29, 1894

---

*Life Members.

CORRESPONDING MEMBERS.

Date of Admission

Ami, Henry M., D. SC., F. G. S., F. R. S. C., Geological Survey, Ottawa
 Ontario ....Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. C. S., Fredericton, N. B. ...Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S. ....Nov. 29, 1871
Barbour, Capt. J. H., R. A. M. C., F. L, S., Nowgong, Bundelkhand,
 Central India. ....Dec. 28, 1911
Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C., Ontario Agri-
 cultural College, Guelph, Ont. ....Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Fredericton, N. B. ....Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England ....Dec. 3, 1897
Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada,
 Ottawa ; Assoc. Memb., March 6, 1888 ....Dec. 3, 1902
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton,
 Mass., U. S. A. ....Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England. (Sole sur-
 viving Foundation Member ; originally elected Dec. 26, 1862,
 and admitted Jan. 26, 1862.) ....Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa ..May 5, 1896
Hay, George U., D. SC. F. R. S. C., St. John, N. B..............Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia ....May 5, 1892
Matthew, G. F., M. A., D. SC., LL. D., F. R. S. C., St. John, N. B.....Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A. ....Nov. 30, 1891
Mowbray, Louis L, Hamilton, Bermuda ....May 3, 1907
Peter, Rev. Brother Junian ....Dec. 12, 1898
Prest, Walter Henry, M. E., Bedford, N. S. ; Assoc. Memb., Nov.
 29, 1894 ....Nov. 2, 1900
Prichard, Arthur H. Cooper, Librarian, Numismatic Museum, New
 York, U. S. A. ....Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries,
 Ottawa, Ontario. ....Jan. 5, 1897

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS
THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS
FOUNDATION ON 31ST DECEMBER, 1862.

	Term of Office.
Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862 to 26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863 " 8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct. 1873 " 9 Oct. 1878
William Gossip	9 Oct. 1878 " 13 Oct. 1880
John Somers, M. D.	13 Oct. 1880 " 26 Oct. 1883
Robert Morrow	26 Oct. 1883 " 21 Oct. 1885
John Somers, M. D.	21 Oct. 1885 " 10 Oct. 1888
prof. James Gordon MacGregor, M. A., D. SC., F.R.S.. F.R.S.C.	10 Oct. 1888 " 9 Nov. 1891
Martin Murphy, C. E., D. SC., I. S. O.	9 Nov. 1891 " 8 Nov. 1893
Prof. George Lawson, PH. D., LL. D., F. I. C., F. R. S. C.	8 Nov. 1893 " 10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov. 1895 " 8 Nov. 1897
Alexander McKay M. A.	8 Nov. 1897 " 20 Nov. 1899
Alexander Howard MacKay, B. A., B. SC., LL. D., F. R. S. C.	20 Nov. 1899 " 24 Nov. 1902
Henry Skeffington Poole, M A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov. 1902 " 18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905 " 11 Nov. 1907
Prof. Ebenezer Mackay, PH. D.	11 Nov. 1907 " 12 Dec. 1910
Watson L. Bishop	12 Dec. 1910 " ————

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the
Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was
held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society
was changed to the Nova Scotian Institute of Science, and it was incorporated by an
act of the legislature in the same year.

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of
the Nova Scotian Literary and Scientific Society about 1859 (the latter published its
Transactions from 4th January to 3rd December, 1859) had led up to the establishment
of the N. S. Institute of Natural Science in December, 1862.

LIST OF MEMBERS, 1913-14

ORDINARY MEMBERS

Date of Admission

Bancroft, George R., County Academy, Halifax.............................Jan. 7, 1908

Barnes, Albert Johnstoue, B. SC., service inspector Maritime Telephone & Telegraph Co., Halifax...May 13, 1912

Bishop, Watson L., Dartmouth, N. S..Jan. 6, 1890

Bowman, Maynard, B. A., Public Analyst, Halifax........................Mar. 13, 1884

Bronson, Prof Howard Logan, PH. D., Dalhousie College, Halifax...........Mar. 9, 1911

Brown, Richard H., Halifax..Feb. 2, 1903

*Campbell, Donald A., M. D., Halifax......................................Jan. 31, 1890

Campbell, George Murray, M. D., Halifax...................................Nov. 10, 1884

Colpitt, Parker R., City Electrician, Halifax..............................Feb. 2, 1903

Creighton, Prof. Henry Jermain Maude, M. A., M. SC., DR. SC., F. C. S., Swarthmore College, Swarthmore, Penn., U. S. A..........................Jan. 7, 1908

*Davis, Charles Henry, C. E., New York City, U. S. A.................Dec. 5, 1900

Doane, Francis William Whitney, City Engineer, Halifax.................Nov. 3, 1886

Donkin, Hiram, M. E., Deputy Com. of Mines, Halifax.................Nov. 30, 189^2

Fergusson, Donald M., chemist, Acadia Sugar Ref. Co., Halifax.............Jan. 5, 1909

*Forbes, John, Halifax..Mar. 14, 1883

*Fraser, C. Frederick, LL. D., Principal School for the Blind, Halifax..........Mar. 31, 1890

Freeman, Philip A., Hx. Elect. Tramway Co., Halifax......................Nov. 6, 1906

Graham, Prof. Stanley Newlands, B. SC., N. S. Technical College, Halifax.....Nov. 28, 1913

Harlow, A. C., Montreal...Jan. 7, 1908

Harris, Prof. David Fraser, M. D., D. SC., F. R. S. E., Dalhousie College, Halifax..Feb. 29, 1912

Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth............Nov. 12, 1892

Irving, G. W. T., Education Dept., Halifax.................................Jan. 4, 1892

Johnstone, J. H. L., Demonstrator of Physics, Dalhousie University, Halifax..Dec. 2, 1912

*Laing, Rev. Robert, Halifax..Jan. 11, 1885

McCallum, A. L., B. SC., analyst, Halifax................................Jan. 7, 1908

McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S...........Dec. 4, 1901

McColl, Roderick, C. E., Halifax...Jan. 4, 1892

*MacGregor, Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh, Scotland (Died May, 1913)...................Jan. 11, 1877

McInnes, Hector, LL. B., Halifax..Nov. 27, 1889

MacIntosh, Donald Sutherland, B. A., M. SC., Dalhousie College, Halifax......Mar. 9, 1911

*McKay, Alexander, M. A., Supervisor of Schools, Halifax..................Feb. 5, 1872

*MacKay, Alexander Howard, B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax..Oct. 11, 1885

Mackay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax.................Nov. 27, 1889

*MacKay, George M. Johnstone, Schenectady, N. Y., U. S. A...............Dec. 28, 1903

MacKenzie, Prof. Arthur Stanley, PH. D., F. R. S. C., Dalhousie College, Halifax..Nov. 7, 1905

*McKerron, William, Halifax..Nov. 30, 1891

Moore, Prof. Clarence L., M. A., F. R. S. C., Dalhousie College, Halifax........Jan. 7, 1908

Morton, S. A., M. A., County Academy, Halifax............................Jan. 27, 1893

Murray, Prof. Daniel Alexander, PH. D., Montreal.........................Dec. 18, 1903

Nickerson, Carleton Bell, M. A., Dalhousie College, Halifax..................Mar. 9, 1911

*Life Members.

Date of Admission

Piers, Harry, Curator Provincial Museum and Librarian Provincial Science
    Library, Halifax..Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., CAN. SOC.
    C. E., HON. MEM. INST. M. E., Guildford, Surrey, England.............Nov. 11, 1872
*Robb, D. W., Amherst, N. S...Mar. 4, 1890
Sexton, Prof. Frederic H., B. SC., Director of Technical Education, Halifax....Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural College, Truro, N. S.; Assoc. Memb.
    Jan. 6, 1890...Dec.   1900
*Stewart, John, M. B. C. M., Halifax.................................Jan. 12, 1885
Winfield, James H., Manager Mar. Tel. & Tel. Co., Halifax ....Dec. 18, 1903
*Yorston, W. G., C. E., Assistant Road Commissioner, Halifax.............Nov. 12, 1892

ASSOCIATE MEMBERS

Allen, E. Chesley, Yarmouth, N. S...................................Nov. 28, 1913
*Caie, Robert, Yarmouth, N. S.......................................Jan. 31, 1890
Connolly, Prof. J. C., PH. D., St. Francis Xavier, Antigonish, N. S...........Nov. 5, 1911
Haley, Prof. Frank R., Acadia College, Wolfville, N. S....................Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S..................Mar. 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S..................May 17, 1899
James, C. C., LL. D., C. M. G., Deputy Min. of Agriculture, Toronto, Ontario...Dec. 3, 1896
Jennison, W. F., Truro, N. S...May 5, 1903
*Johns, Thomas W., Yarmouth, N. S..................................Nov. 27, 1889
*MacKay, Hector H., M. D., New Glasgow, N. S.........................Feb. 4, 1902
Payzant, E. N., M. D., Wolfville, N. S.................................Apr. 8, 1902
Perry, Prof. Horace Greeley, M. A., Acadia University, Wolfville, N. S........May 12, 1913
Pineo, Avard V., LL. B., Kentville, N. S...............................Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis, N. S..................Jan. 31, 1890
*Robinson, C. B., PH. D., New York Botanical Garden, New York, U. S. A.
    (Died 1913)...Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S...................Nov. 29, 1894

*Life Members.

CORRESPONDING MEMBERS

Date of Admission

Ami, Henry M., D. SC., F. G. S., F. R. S. C., Geological Survey, Ottawa, Ontario..Jan.　2, 1892

Bailey, Prof. L. W., PH. D., LL. D., F. R. S. C., Fredericton, N. B.............Jan.　6, 1890

Ball, Rev. E. H., Tangier, N. S......................................Nov. 29, 1871

Barbour, Capt. J. H., R. A. M. C., F. L. S., Nowgong, Bundelkhand, Central
　　India. ....Dec. 28, 1911

Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C., Ontario Agricultural
　　College, Guelph, Ontorio.......................................Dec. 29, 1868

Cox, Prof. Philip, B. SC., PH. D., Fredericton, N. B.......................Dec.　3, 1902

Dobie, W. Henry, M. D., Chester, England.............................Dec.　3, 1897

Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa;
　　Assoc. Memb. March 6, 1888....................................Dec.　3, 1902

Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass. U.S.A.Jan.　6, 1890

Hardy, Maj-General Campbell, R. A., Dover, England. (Sole surviving
　　Foundation Member; originally elected Dec. 26, 1862, and admitted
　　Jan. 26, 1862.)...Oct. 30, 1903

Hay, George U., D. SC., F. R. S. C., St. John, N. B. (Died 1913)..............Dec.　3, 1902

Matthew, G. F., M. A., D. SC., LL. D., F. R. S. C., St. John, N. B.............Jan.　6, 1890

Mowbray, Louis L., Hamilton, Bermuda...............................May　3, 1907

Peter, Rev. Brother Junian..Dec. 12, 1898

Prest, Walter Henry, M. E., Bedford, N. S.; Assoc. Memb., Nov. 29, 1894.....Nov.　2, 1900

Prichard, Arthur H. Cooper. Librarian Numismatic Museum, New York, USA.Dec.　4, 1901

Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa.Jan.　5, 1897

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIA INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION ON 31ST DECEMBER, 1862.

Term of Office.

Hon. Philip Carteret Hill, D. C. L............................	31 Dec. 1862 to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C......................	26 Oct. 1863 "	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.................	8 Oct. 1873 "	9 Oct. 1878
William Gossip..	9 Oct. 1878 "	13 Oct. 1880
John Somers, M. D.....................................	13 Oct. 1880 "	26 Oct. 1883
Robert Morrow..	26 Oct. 1883 "	21 Oct. 1885
John Somers, M. D.....................................	21 Oct. 1885 "	10 Oct. 1888
Prof. James Gordon MacGregor, M.A., D.SC., F.R.S., F.R.S.C.....	10 Oct. 1888 "	9 Nov. 1891
Martin Murphy, C.E., D.SC., O.S.I.........................	9 Nov. 1891 "	8 Nov. 1893
Prof. George Lawson, PH.D., LL.D., F.I.C., F.R.S.C.............	8 Nov. 1893 "	10 Nov. 1895
Edwin Gilpin, Jr., M.A., LL.D., D.SC., F.G.S., F.R.S.C., I.S.O.......	18 Nov. 1895 "	8 Nov. 1897
Alexander McKay, M.A.................................	8 Nov. 1897 "	20 Nov. 1899
Alexander Howard MacKay, B.A., B.SC., LL.D., F.R.S.C.........	20 Nov. 1899 "	24 Nov. 1902
Henry Skeffington Poole, M.A., D.SC., A.R.S.M., F.G.S., F.R.S.C....	24 Nov. 1902 "	18 Oct. 1905
Francis William Whitney Doane, C.E......................	18 Oct. 1905 "	11 Nov. 1907
Prof. Ebenezer Mackay, PH.D............................	11 Nov. 1907 "	12 Dec. 1910
Watson Lenley Bishop..................................	12 Dec. 1910 "	11 Nov. 1912
Donald MacEachern Fergusson, F.C.S......................	11 Nov. 1912 "	————

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its Transactions from 4th January to 3rd December, 1859) had led up to the establishment of the N. S. Institute of Natural Science in December, 1862.

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